Conservation and Stewardship Plan for the

Crum Woods

of Swarthmore College

prepared by

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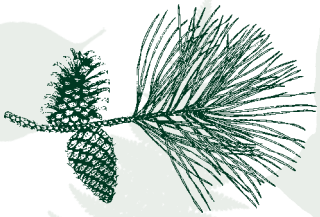

CONTINENTAL CONSERVATION

December 2003

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Introduction

The Crum Woods of Swarthmore College are significant not only for their large area, but also for the high diversity and good health of the natural habitats that occur there. In recognition of the value of this unique resource, in 2000 the College formed the Crum Woods Stewardship Committee. The Committee's purpose is to address concerns about the current state of the Crum Woods, about communication between faculty and land managers, and about potential trade-offs between future facilities development and particular areas of special importance for teaching, research and aesthetic appreciation. The Committee's vision, as stated in its request for proposals, is that

> *In light of Swarthmore College's educational mission and its commitment to social responsibility, the woods and creek should be restored and managed to yield the maximum sustainable pedagogical benefits and meet the highest realistically achievable standards of environmental quality. Future generations of students should be able to enjoy and learn in a variety of ecological communities with the character of the vegetation and wildlife before European settlement — healthy, functioning ecosystems dominated by native species and exhibiting the dynamic processes typical of the region's landscape, including natural disturbances.*

In the Spring of 2001, the Committee engaged Natural Lands Trust and Continental Conservation to prepare a *Conservation and Stewardship Plan for the Crum Woods*. The purpose of this Plan is to provide the Crum Woods Stewardship Committee with information and recommendations needed to address current management concerns within the Crum Woods and to guide future management to meet the pedagogical, ecological, and recreational needs of the Swarthmore College community.

The study area is in two tracts (Figure 1) totaling 220 acres (89 ha), just under three-fifths of the College's total land area of approximately 367 acres (149 ha). The Campus Woods (Figure 2) are approximately 190 acres (77 ha) of mostly forested land straddling Crum Creek adjacent to campus, including the Crum Ledge apartments and four College-owned residences along Harvard Avenue, the lawns and meadows between Strath Haven condominiums and the creek and in Crum Meadow (also known as Palmer Meadow), the partly wooded area east of the Victoria Road-Wallingford Road intersection in Springfield Township, and all of the College's land on the west side of Crum Creek in Nether Providence Township. Martin Forest, the second tract, is an almost entirely forested 30 acres (12 ha) along the east side of Crum Creek in Springfield Township about a mile north of campus, donated to the College in 1926 by Dr. Edward and Anna Martin. The Martin Forest has been leased to Delaware County

since 1941 to serve as a nature reserve section of Smedley Park. Throughout this document, the term Crum Woods or "the Woods" refers to both tracts together; the designations Campus Woods and Martin Forest are used where they are mentioned separately. Pertinent information was gathered from published sources, field studies, and discussions with, and surveys of, representatives of numerous stakeholder groups,[1] including alumni, faculty, students, staff, volunteers, and members of the wider community (Appendices A, B, C and D).

Within the Crum Woods, areas that are relatively undisturbed by humans and feature outstanding or unusual natural assets have the greatest value for teaching, research, contemplation and appreciation of nature, and other "ecosystem services." Such assets include natural community types or populations of species that are rare or otherwise of special interest, relatively small areas with an exceptionally high diversity of natural community types or of plant or animal species, and intact landscapes where human influence is unusually mild. Collectively these parts of the Crum Woods are ecologically significant at a regional scale; they are some of the best remaining natural areas in the Philadelphia metropolitan area. In this document, boundaries are drawn around these special-value lands and they are termed Natural Areas, spelled with capital letters to distinguish the special designation of particular units of land from other, generic uses of the phrase. Natural Areas are not the only units of land in the Crum Woods that have a high priority for conservation, but they generally merit the highest rank. Other lands may rank nearly as high, including riparian forest buffers, other wetlands, functioning forest interior, and forest stands contributing to the integrity of large, contiguous blocks of forestland.

This plan's foundation and opening section is an inventory of the physical and biological resources and current human uses of the Crum Woods. Next is a discussion of how best to prioritize resource-protection efforts, based on present and potential utilization of the Woods, in support of the College's mission. This is followed by an enumeration of threats and sources of stress that affect the capacity of the Woods to continue delivering high-quality benefits. General recommendations are then provided on approaches and methods for sound stewardship and for dealing with specific threats. These are followed by a classification of the entire Crum Woods area into land management units based on land use, conservation priority, resources, surrounding influences, and existing and potential problems and stresses. This section includes a description of each management unit and its conservation issues and opportunities along with detailed restoration and management recommendations. The report concludes with recommendations for a practical monitoring program designed to evaluate, routinely and systematically, progress toward achieving the conservation goals.

[1] Stakeholders are people who will be affected by, or who will affect, management decisions and outcomes.

1.0 Inventory

1.1 THE SETTING FOR ECOLOGICAL PROCESSES

1.1.1 Physiography and topography

The Crum Woods are located in the Piedmont Upland section of the Piedmont province (Berg et al. 1989). The Piedmont is the low, hilly plateau stretching from southeastern New York to the center of Alabama — the eastern and southern foothills of the central and southern Appalachians. The College sits at the Fall Line — the escarpment where the outer edge of the Piedmont Plateau drops off about 200 ft. (60 m) in elevation to the adjoining Atlantic Coastal Plain. Piedmont rivers and creeks embellish the Fall Line in some places with waterfalls and in others, including Crum Creek's passage, with steep-sided gorges. The Piedmont Upland reaches its northeasternmost limit in southern Bucks County, Pennsylvania, extending westward across most of Delaware and Chester Counties through southern Lancaster and York Counties, and southward through northern Delaware and central Maryland. It is distinguished by half-billion-year-old metamorphic bedrock with extremely complex folds and faults, in contrast to the younger, less convoluted sedimentary rocks of the rest of the Piedmont and all other nearby physiographic regions.

Elevations in the Crum Woods range from just over 40 ft. (12 m) above mean sea level at the edge of Crum Creek above the Yale Avenue-Rose Valley Road bridge to about 250 ft. (75 m) on the upper slopes of Martin Forest (the Smedley Park tract). For comparison, the train platform at Swarthmore Station is at 137 ft. (41.8 m) and the flagstones in front of Parrish Hall at the top of Magill Walk are at 204 ft. (62.2 m). The largest flat area is the Crum Meadow from "Crumhenge" east to the bend in the creek, with an average slope of less than 0.5%. The entire Crum Meadow, about 6 acres (2.5 ha) altogether, is the widest of several nearly level strips of floodplain and other wetlands within the College's boundary totaling about 30 acres (12 ha). The largest piece of gently sloping land is the top of the Swarthmore Farm Plateau, about 15 acres (6 ha). Nearly all of the rest of the Crum Woods is moderately to steeply sloping. The steepest slope is at Alligator Rock, where the middle one-third of the hillside tilts at more than 75% and the entire 143-vertical-foot (43.6-m) drop from the road behind Cornell Library to the creek averages nearly 50%.

1.1.2 Bedrock and soils

Two bedrock formations lie beneath the Crum Woods (Berg and Dodge 1981). An oligoclase-mica schist of the Wissahickon Formation covers most of the area. The rock is a highly micaceous phyllite composed of the minerals quartz, feldspar, muscovite and chlorite (Geyer and Wilshusen 1982). Abundant mica gives the gray or greenish-gray rock a distinctive sparkling sheen. Loose material is in small, flattened pieces of rubble with a surface of minute grooves and ridges. The bedrock has low permeability to water.

The other bedrock formation covers a much smaller area but it is better known because it forms massive outcrops and cliffs, as at Alligator Rock. It is a hornblende-bearing mafic gneiss, which forms a narrow, north-south oriented stripe just east of and roughly parallel to Crum Creek. The rock is dark gray and composed of the minerals calcic plagioclase, hypersthene and augite, with inclusions of quartz (Geyer and Wilshusen 1982). Loose material is in large, smoothish, rectangular blocks. Because gneiss is more resistant to erosion than schist, this formation acted as a dike, deflecting the southeastward-trending Crum Creek as it sliced down through bedrock to form its gorge. The wall of gneiss forced the creek into a generally southward alignment in the 3.5 stream miles (5.6 km) from the north end of Smedley Park to just above the Chester Road bridge. As the adjacent schist erodes away, gneiss forms highly stable slopes, often so steep that soil does not form or is quickly carried away by rain and gravity, resulting in dramatic outcrops. The outcrops are scattered along the eastern wall of the gorge where the stream meanders closest to the gneiss: part of Martin Forest, the stream bend near Ogden Avenue, Alligator Rock, the stream bend near Crum Ledge apartments, and the slopes near Cratsley House. The same line of gneiss also outcrops on the slopes along Yale Avenue down the hill from Mary Lyon Residence Hall. The north end of a parallel, much shorter band of gneiss is visible on the west side of Crum Creek across from the middle of Crum Meadow.

Both bedrock types weather into moderately acidic loams and silt loams (Kunkle 1963); these categories are dead-center in the spectrum of soil texture, neither sandy nor high in clay content. The soils have moderate water-holding capacity and drain fairly rapidly when wetted by rain, especially on slopes. Where quartz is more abundant — for example, on Hogback Knoll on the west side of Crum Creek under the railroad trestle — soils are sandier and more rapidly draining, and thus tend to be drier.

The gorge slopes are underlain by loams of the Manor series (Kunkle 1963), classified as coarse-loamy, micaceous, mesic Typic Dystrochrepts (Custer 1983). Depth ranges from as little as one foot (30 cm) over gneiss up to 10 ft. (3 m) in flat areas over schist. Steep slopes and isolated areas like Hogback Knoll were probably never used for agriculture; here the native soil profiles and microbial communities are most likely intact and may have changed little in thousands of years. Soils of the Manor series are not well suited to growing crops but, nevertheless, some moderate to gentle slopes show evidence of

having been cropped or pastured. In those places tree removal, plowing, the planting of crop or forage monocultures, and resulting increases in soil erosion rates destroyed the original soil profile and microbial communities.

The gentle slopes atop the Swarthmore Farm Plateau are underlain by channery silt loams of the Glenelg series, classified as fine-loamy, mixed, mesic Typic Hapludalfs. These are moderately deep, well-drained soils whose mineral component is weathered from mica schist. They are well suited to agriculture and in central Delaware County were usually used to grow corn and other grains, alfalfa, clover and hay grasses. The original soil profile has in most cases been destroyed by centuries of plowing. Nutrient depletion, erosion, and the absence of native plant species have altered and greatly simplified the soil animal and microbial communities. This is reflected in reforested areas by low overall plant species diversity and an abundance of introduced invasive species.

In the floodplains along Crum Creek, the bedrock is covered by a deep mantle of alluvium — that is, soil and other material dislodged from slopes by rain and snowmelt, transported by stream flow, and dropped by ebbing floodwaters — and there is little *in situ* weathering. Floodplain soils tend to be silty but because of the flat terrain and frequent floods they often drain very slowly. This results in mottling, that is, the formation of interspersed multicolored regions arising from prolonged saturation and localized anoxic, reducing environments. The soils are silt loams of the Chewacla, Melvin and Wehadkee series, strongly heterogeneous at a small spatial scale and classified as various Fluvaquents and Udifluvents.

Soils underlying the edges of the campus, roads and other areas subjected in the past to large-scale earthmoving are placed in the category "made land, schist and gneiss materials" and classified as Udorthents. Soil profiles have been upended or severely truncated and often soil and rock from elsewhere, building materials, and other debris are mixed in.

1.1.3 Climate and hydrology

The Crum Woods are near the center of the temperate latitudes and are subject to extremes of weather during the course of each year. Mean daily maximum and minimum temperatures for the 30 years from 1961 to 1990 were 86.1°F (30.1°C) and 67.2°F (19.6°C) in July and 37.9°F (3.3°C) and 22.8°F (–5.1°C) in January at the nearest weather-recording station, 7 mi. (11 km) east-southeast of Swarthmore (Owenby and Ezell 1992). Mean annual precipitation from 1961 to 1990 was 41.4 inches (105 cm). Precipitation occurs fairly evenly throughout the year, with a dip in September-February (1961-1990 mean 3.07 inches [7.80 cm]) and a peak in July and August (1961-1990 means 4.28 inches [10.9 cm] and 3.80 inches [9.65 cm]). The winter months are the driest because cold continental air masses drifting south from Canada dominate the atmosphere's circulation and they carry little water vapor (Gelber 1992). In summer,

water-saturated tropical air masses set the stage for heavy downpours in localized, mostly afternoon thunderstorms. Occasionally a Caribbean tropical storm or hurricane moves up the Atlantic coast and brings heavy rains in July, August or September. For the 100 years from 1856 to 1955 at a weather-recording station 13 mi. (21 km) west-northwest of Swarthmore, the mean length of the growing season was 190 days. The average date of the last killing frost in spring was 16 April and the average date of the first killing frost in fall was 23 October (Kunkle 1963).

Global climate change was the rule long before human industrial activity played a role. Taking the long view, the area now known as the mid-Atlantic region of eastern North America has been tropical or subtropical for nearly all of the time since the world's first forests appeared over 365 million years ago. It is "only" in the last 10 million years or so that cold winters have been a part of the local climate. Since about 2 million years ago, the situation has been wildly unstable. That period has seen at least eight episodes of global cooling severe enough to cover part of what is now Pennsylvania with year-round ice. These ice ages have alternated with warmer interglacial periods characterized by hot summers and freezing winters, including the present interglacial, called the Holocene, which began about 10,000 years ago. Even within ice ages and interglacials the global climate undergoes fairly dramatic changes. The warmest part of the Holocene was the so-called Hypsithermal Interval about 8,000 to 4,500 years ago, a few degrees warmer and substantially dryer in eastern North America than today (Deevey and Flint 1957; Anderson et al. 1989; Haas and McAndrews 2000). A lesser warm, droughty interval occurred between about 1,000 and 800 years ago. From the mid-1500s to the late 1800s, the earth cooled in what is known as the Little Ice Age, with major consequences for people living at high latitudes worldwide. Accurate daily temperature records have been kept in Philadelphia since 1825, and show that the coldest decade of the last 177 years was the 1830s (Gelber 1992). Temperatures gradually rose for 30 years, plunged again during the 1870s, resumed their upward climb in the 1890s, and reached a peak in the 1930s, a torrid decade with catastrophic droughts. The climate cooled again in the 1940s, warmed in the 1950s, cooled in the 1960s, and resumed warming in the 1970s except for the winter of 1976-1977, which included Philadelphia's coldest month on record. Warming accelerated a decade later and the 1990s surpassed the 1930s to rank as the warmest decade on record. Most climatologists predict continued global warming at an even faster pace, most likely due at least in part to human industrial activities, for the foreseeable future. Meantime, the earth's climate machine continues to run in the background, and no one can confidently forecast whether its oscillations will intensify the predicted warming trend, stay uninvolved, or counteract it.

Groundwater levels show strong seasonal variation (Geyer and Wilshusen 1982), ordinarily highest in early spring. An 1863 assessment of the suitability of the present campus area as a site for a college mentioned "ample springs" and a springhouse (Hull, undated). After the present site was selected and the land purchased, a description presented on 5 December 1864 to the Board of Managers included this sentence: "It also

contains three valuable springs adjacent to each other with an ample supply of water and sufficient power to force it to a suitable elevation" (Hull, undated). Only one spring is known in the Campus Woods today — an underground seep with very low output near Lang Music Building, indicated only by a dense growth of hydrophytes (obligate wetland species) including skunk-cabbage, *Symplocarpus foetidus*. Groundwater is generally at or near the surface in Oxbow Swamp (beneath the railroad trestle) and portions of Skunk-cabbage Hollow (near the Mullan Tennis Center) and floodwaters remain ponded for extended periods at the same sites.

Crum Creek accounts for most of the surface water in the Crum Woods. When there is no storm or drought, the part of the creek between the bridges at the north and south ends of campus averages 30 ft. (9 m) in width, 2 ft. (0.6 m) in depth (Cushman and Lowe 1971), and covers about 11 acres (4.5 ha). The watershed upstream and upslope from the dam at Strath Haven Lake, at the downstream end of the Campus Woods, covers approximately 32.3 sq. mi. (82.7 km^2) in parts of 12 townships and boroughs in Delaware and Chester County (U.S. Army Corps of Engineers 1974; see Figure 3). Dicks Run is the second-largest stream. It meanders for 0.35 mi. (0.57 km) along the College's southwestern boundary and meets Crum Creek just below the Yale Avenue-Rose Valley Road bridge. Its watershed covers about 0.57 sq. mi. (1.5 km^2) in Nether Providence Township and the borough of Media. Two unnamed, first-order perennial streams run from the built-up part of campus through the Campus Woods and into Crum Creek. The mouth of one is south of the Crum Ledge apartments. Its 0.04-sq.-mi. (0.1-km^2 or 25-acre [10-ha]) watershed includes a part of the south campus roughly bounded by Wharton Hall, Parrish Hall, Sharples Dining Hall, Roberts Hall and the south end of Clothier Field. The other stream feeds into Crum Creek southwest of Elm Avenue and northwest of DuPont Science Building. It drains 0.03 sq. mi. (0.07 km^2 or 18 acres [7.3 ha]), roughly including the western half of the block between Elm and Ogden Avenue and Walnut and Cedar Lanes, the houses along Elm Avenue west of Whittier Place, the buildings along Whittier place, DuPont parking lot, and the campus water tower. A third perennial stream flows through and joins Crum Creek in Martin Forest. Its 0.15-sq.-mi. (0.38-km^2 or 93-acre [38-ha]) watershed includes most of the residential areas south of Beatty Road and west of Sproul Road, and the mostly forested, 27-acre (11-ha) Jane Lownes Park. The study area also includes a half-dozen or more intermittent streams with watersheds of 15 acres (6 ha) or less, including two in Martin Forest.

Annual actual evapotranspiration (Table 1), computed from temperature, precipitation and estimated soil water storage, accurately predicts primary (plant) productivity (Major 1963; Rosenzweig 1968). In years of near-average precipitation and temperature, plants pump enough water out of the soil that moisture unavailability is somewhat limiting to primary productivity and plant growth from June through September (Table 1). During droughts, the magnitude of the soil water storage deficit is greater and the period of productivity and growth limitation can increase to encompass more of the growing season. In years of wetter-than-average weather, the difference between actual and potential evapotranspiration may shrink or disappear, but severely wet weather

Table 1. Average monthly climatic water balance data for Philadelphia, based on 1915-1960 weather data (Thornthwaite 1964). All values are given in mm per unit of time. Actual evapotranspiration is equal to potential evapotranspiration when precipitation is greater than the plants' need for water. When soil moisture storage drops below the soil's water-holding capacity, actual evapotranspiration is equal to precipitation plus whatever additional moisture the plants can remove from the soil. Moisture becomes harder for the plants to absorb as the soil becomes drier. Plants are assumed to be able to extract moisture from the soil in the same proportion as the ratio of actual soil moisture content to the moisture content at maximum field capacity. For example, if the moisture content is 50% of the total available at field capacity, the rate of removal by plants is assumed to be 50% of the amount the plants actually need. Water surplus is the amount of precipitation that falls when the moisture in the soil is already at field capacity. Water deficit is the amount by which potential evapotranspiration exceeds actual evapotranspiration.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
potential evapotranspiration	0	2	15	43	93	131	156	138	91	55	20	5	749
precipitation	83	80	89	83	86	90	105	118	85	72	78	79	1,048
soil moisture storage	300	300	300	300	293	255	215	201	193	210	268	300	—
actual evapotranspiration	0	2	15	43	93	128	145	132	93	55	20	5	731
water deficit	0	0	0	0	0	3	11	6	4	0	0	0	24
water surplus	83	78	74	40	0	0	0	0	0	0	0	42	317

can lead to other limitations on productivity. For example, the unavailability of light to leaves can limit growth in unusually cloudy weather and soil saturated for long periods can cut off the oxygen supply to roots.

1.1.4 Water quality

The headwaters of Crum Creek, from the source to just above West Chester Pike (Pa. Route 3) has been designated by the Pennsylvania Department of Environmental Protection (D.E.P.) as a "high quality stream," owing to the watershed's low percentage of impervious coverage and relatively intact network of riparian woodlands (Figure 3). The creek in this area supports a higher diversity of aquatic organisms than farther downstream (Pennsylvania Fish and Boat Commission 1999; Pennsylvania Department of Environmental Protection 2000). Nearly 19 mi. (30 km) of Crum Creek and its tributaries are rated by D.E.P. as "impaired" due to agricultural impacts, habitat modifications, urban runoff and dams. Crum Creek and its tributaries below the Springton Reservoir are designated as "warm water fishery" streams. The creek is subject to nonpoint-source pollution associated with various levels of suburban and urban runoff and extensive areas of impervious cover. Part of lower Crum Creek has also been identified as significantly impacted by thermal modification (i.e., heated substantially above normal temperature levels), presumably due mainly to the presence of two water-supply reservoirs where there is no shade to prevent solar heating. Diminished groundwater recharge and discharges from sewage treatment plants are also likely contributors.

Crum Creek's 32.3-sq.-mi. (82.7-km^2) watershed above the lower end of College property is a still-growing suburban area of residential, commercial and light industrial land uses (Figure 3). Streamwater tends to be turbid from silt and other suspended solids, owing to runoff from construction sites, eroded slopes, and deforested riparian zones (Cushman and Lowe 1971; Pennsylvania Fish and Boat Commission 1999; Pennsylvania Department of Environmental Protection 2000). The water chemistry is suitable for a more diverse and productive community of aquatic organisms but the turbidity and bottom accumulation of silt limit primary productivity (photosynthesis), resulting in lower biomass and diversity of algae and other aquatic plants. All other organisms are dependent on primary producers either directly or indirectly, and so their biomass and diversity are restricted in turn. Siltation also cuts down structural diversity by limiting the availability of aquatic vascular plants, clean rocks and gravel to animals as attachment and breeding sites, further reducing the species carrying capacity. Only 10 sq. mi. (26 km^2) of the watershed above College property is below the high dam at Springton Lake, but it is the most highly urbanized section and contributes large quantities of flood-borne trash, which accumulates at logjams and along the floodplain in the Crum Woods. Flood-deposited and floating trash probably has little effect on ecosystem health but it is a severe aesthetic problem.

1.1.5 Land-use history and other human influences on the landscape and its component ecosystems

The land-use history of the Crum Woods can be traced back at least 13,000 years, when the local ecosystem first experienced the effects of *Homo sapiens*. Contrary to a long-held popular belief, research by paleobiologists and recent work by ecologists suggest that early human impacts on eastern North American ecosystems were very likely profound. The effect that is most obvious from the fossil remains was the extinction of more than two dozen species of "megafauna" — large mammals — within a few centuries of the arrival of the first humans. A probable effect not easily detected in the fossil record is a cascade of ecological changes resulting from the removal of the largest grazers, browsers and predators. Such animals are often keystone species where they survive in present-day ecosystems. A keystone species is one whose effects are much greater than would be expected from its relative population abundance, and whose removal leads to the loss of many other species in a community.

Besides the familiar white-tailed deer, elk, and moose, other large browsers and grazers in the Crum Woods landscape included two extinct deer species, three peccaries (at least one as large as, or larger than, the introduced wild boar of the southeastern United States), the American bison, the giant horse, two tapirs, the black-bear-sized giant beaver, two elephant-sized giant ground sloths, and two elephants, the American mastodon and woolly mammoth (Cope 1871, 1899; Wheatley 1871; Hay 1923; Guilday 1971; Kurtén. and Anderson 1980; Williams at al. 1985). Their presence during 99% of the current geological period is reflected in coevolved plants that still live here. For example, honeylocust, *Gleditsia triacanthos*, which lives in Skunk-cabbage Hollow, bears huge, sweet bean pods — scarcely touched by any surviving animal species — and defends its trunk with foot-long, multi-pronged thorns against bark-stripping animals, which no longer exist (Barlow 2000). With the woods and grasslands teeming with such plentiful sources of meat, large predators also abounded. In addition to the black bear, gray wolf and mountain lion, eliminated from the Crum Woods only 300 years ago, there were three other wild dog species, two cheetahs, the jaguar (now confined to tropical America), and three other bears, including the grizzly bear (now confined to western North America), and the extinct giant short-faced bear, the largest land predator the earth has seen since the demise of the dinosaurs.

Human occupation may have had little effect from about 10,000 years ago, by which time nearly all of these animals were gone, until sometime around 2,000 years ago, when another human activity began to effect large-scale ecological change. Fossil pollen preserved in bogs and lake sediments all across the eastern half of North America shows the beginnings around this time of wide-scale burning. Native Americans found they could improve the ease of travel, hunting and defense and promote the growth of animal and plant species prized as food by wielding fire as a powerful land-management tool (Maxwell 1910; Day 1953; Thompson. and Smith 1970; Webster 1983; Dent 1985; Denevan 1992; Casselberry and Evans 1994; Black and Abrams 2001). The

oak-dominated forests that persist today and native grasslands, most of which disappeared soon after Native Americans were ousted from the land, almost certainly owe their existence to traditions of large-scale burning among some groups of people for centuries or thousands of years before the arrival of Europeans (Marye 1955; Russell 1983; DeSelm 1986; Abrams 1992; Clark and Royall 1996; Clark et al. 1996; Delcourt and Delcourt 1997, 1998; Delcourt et al. 1998). Ironically, by employing fire to change the landscape humans undid some of the damage our species had perpetrated on biodiversity thousands of years earlier. The vast oak-chestnut-hickory forests born out of the flames sustained a higher total biomass, and in all likelihood a higher diversity, of animal life with their massive crops of fat- and protein-rich nuts and acorns than the mixed forests that preceded them. Fire also restored some of the grassland, which had been far more widespread before the human-caused extinction of nearly all of the large herbivores.

Knowledge of the particular events and personalities of the first 13,000 years of the area's human occupancy is lost forever. We can infer only dim outlines of what life may have been like in the Crum Woods and vicinity in those times, relying on sparse archaeological evidence gathered from across a much larger region, and by reading between the biases of the first European chroniclers and extrapolating backward in time. For 90% of the time that humans have lived in the area, they were sparsely populated hunters and gatherers living in small bands and moving seasonally to take advantage of shifting concentrations of wild food resources such as berries, nuts, migrating waterfowl, and fish. The local archaeological record from this time is sparse. To date, only 189 prehistoric cultural sites have been investigated by archaeologists in an 884-sq.-mi. (2,260 km^2) area including all of Delaware County and some of the surrounding area, but none is in the Crum Woods or anywhere in Swarthmore borough, Springfield or Nether Providence townships (Berge et al. 1991). The first time any of the land in the vicinity was cleared for crops was roughly 1,000 years ago, when people in the region began cultivating corn, beans, squash, sunflowers and other crops on a scale large enough to show up in the archaeological record (Tuck 1978). Any farming practiced within the area of the present-day Crum Woods by Native Americans was almost certainly confined to small areas of Crum Creek's floodplain (Berge et al. 1991).

By late prehistoric times, the Lenape or Delaware Indians lived in scattered villages and family compounds consisting of small, windowless, bark wigwams, surrounding garden plots, and, in the larger settlements, a special longhouse built for ceremonies and conferences (Weslager 1972). Villages and seasonal camps were moved fairly often. Several such settlements most likely occupied some of the flat areas along Crum Creek for a few years at a time through the centuries, although traces have never been found within College lands (Berge et al. 1991). This is partly because no one has looked very hard (Berge et al. 1991) and partly because flood scouring and siltation have greatly increased on these sites during historic times due to massive land-use changes in the watershed (the near-total removal of the original forest, large-scale tillage, and, more

recently, the covering of large areas of soil by impervious surfaces including buildings, roads, and parking lots). Both when villages were present and when they were not, the Woods most likely were continuously part of one or more hunting territories, with the right of use held communally by a nearby Lenape family or village. Lenape land-use rights were quite different from Western notions of land ownership, but they were generally known and respected by holders of hunting rights on neighboring territories (Weslager 1972).

Recorded history with direct relevance to the Crum Woods started in 1633. Then, as now, events considered worthy of reporting were likely to be violent. The earliest known European visitors to present-day Delaware County, Dutch traders sailing up the Delaware River to barter with the natives for badly needed food, reported a war in progress (Weslager 1972; Kent 1993). The Susquehannock or Minquas Indians, an Iroquoian-speaking people and ethnically very different from the Lenape, were making forays from their large, palisaded towns along the lower Susquehanna in present-day Lancaster and York Counties, Pennsylvania, to terrorize and subdue the more rural people in present-day Delaware, Philadelphia, and Bucks Counties. The locals were of various Unami (downriver) tribes of the Lenape, an Algonquian-speaking people living in the Delaware River valley and southeastward to the Atlantic coast. The Lenape vastly outnumbered the Susquehannocks but they were far less organized — each village was politically autonomous — and more predisposed to hospitality than warfare. The Susquehannocks' terror campaign killed many Lenape and caused others to flee their homes. The motives for the Susquehannocks' attacks apparently were to monopolize the fur trade with the newly arrived Dutch and Swedes and to preempt the Iroquois, their ethnic cousins but bitter enemies, who were in the process of subduing other Algonquian-speaking peoples in New York and northern New Jersey and may have had their own designs on the lower Delaware valley. The Great Minquas Path, which connected the Susquehannock towns on the Susquehanna with the European trading posts on the Schuylkill and Delaware, crossed Crum Creek in or near the Crum Woods. The trail is known to have forded Ridley Creek at Long Point in Rose Valley and crossed through or past Swarthmore to Darby. It is likely that people carrying loads of furs and other trade goods or weapons would have avoided a route requiring a steep descent and ascent across Crum Creek's gorge; the easiest and most likely crossing is near the mouth of Dicks Run (near the present-day Yale Avenue-Rose Valley Road bridge).

In the 1630s, the native population was decimated by smallpox and other European diseases to which they had little resistance (Sultzman 2000), by the Susquehannocks' attacks on the Lenape, and by massive warfare between the Susquehannocks and the Iroquois (Weslager 1972; Kent 1993). By the time Europeans took up permanent residence in what is now Delaware County 360 years ago, hostilities between the Susquehannocks and Lenape had ended, in part, perhaps, because so few Lenape were left. In 1643, a group of Swedes, with a few accompanying families of Finns, set up Pennsylvania's first colonial settlement, New Gottenburg, near the mouth of Crum

Creek on Tinicum Island (at present-day Essington, which is no longer an island due to extensive earthmoving leading up to the construction of the nearby Philadelphia International Airport). A second, smaller Swedish and Finnish settlement followed within a year or two at Upland, along Chester Creek near its mouth 3 mi. (5 km) southwest of Swarthmore (present-day Upland and downtown Chester). The first water-powered mill within the modern borders of Pennsylvania was a gristmill built in 1643 on Crum Creek, just below what is now the interchange between I-95 and I-476 (Ashmead 1884).

Nearly 40 years of governmental mismanagement and persistent bad fortune followed, with periodic outbreaks of violence among Swedish, Dutch, and English military forces and between European settlers and the resident Native Americans (Ashmead 1884; Ward 1930). New Sweden became New Netherlands, was in turn conquered by the English, briefly reverted to Dutch control, then back to English. During this tumultuous period the land that would become the College and Crum Woods was most likely used by the Swedish, Finnish, few remaining Lenape and, later, English people living nearby much as it had been for thousands of years — as an area for hunting game and gathering useful wild plants. For reasons that are unknown today, during the period of Swedish settlement no Europeans settled more than a mile or two from the Delaware River (Berge et al. 1991). The stream that the Swedes called Crumkill or Cromkill ("crooked creek") was known to the natives as Ockanickon (Donehoo 1928), and, in turn, the native peoples living in the lower Crum and Ridley Creek valleys were called the Ockanickon tribe or band, or sometimes variations such as Okehocking. A Swedish colonial mapmaker pinpointed many Lenape villages in and surrounding the entire Swedish colony but somehow the names and locations of the Ockanickon villages were never recorded (Weslager 1972).

Actual settlement by Europeans on what are now College lands did not occur until 1681 and 1682, when William Penn's proprietary government issued patents conveying nearly all of the land to colonial farmers and other settlers; most, if not all, were English members of the Society of Friends. In the two decades from the early 1680s to just after 1700, they cleared the forest from nearly all but steeply sloping land to establish their plantations. This started the period of intensive agriculture, which lasted more than 160 years until the founding of the College on the east side of Crum Creek, and 80 years longer on the west side. Farmers in the English colonial period and into the early nineteenth century were able to produce substantial surpluses for trade. Grains, vegetables, livestock, tobacco and other products were sold in Philadelphia, Chester and other nearby markets and exported to other colonies and even Europe (Berge et al. 1991). Later, in the nineteenth and early twentieth centuries, the fields were mainly planted in corn, alfalfa, clover, hay grasses, and other grains or used as pasture (Kunkle 1963).

As the English immigrants settled farther and farther inland from the Delaware River, the remaining Native American residents moved their summer quarters farther up the

creeks. In the fall of 1700, the Ockanickon band petitioned the Provincial Council for "a secure tract of land, bounded in the English fashion" (Becker 1998), that is, they proposed adopting the European notion of land ownership in an attempt to maintain good relations with their neighbors.

> *The Ockanickon or Crum Creek Indians having removed from their old habitation before the Proprietors Departure, by his Order Seated, by Caleb Pusey, etc. … But the said Indians expressing great uneasiness at the uncertainty of their Settlements, pressed and several times Urged the Neighboring Friends that they might be Confirmed in Some particular place unter [sic] certain Metes and Bonds [sic], that they Might live no more like Dogs, as they expressed themselves. (Pennsylvania Archives, Second Series, Vol. XIX, p. 341, quoted in Donehoo 1928.)*

By the time that they returned from winter hunting the Proprietary government had surveyed a tract of 500 acres (2 km^2) exclusively for their use. Caleb Pusey, one of the group of men assigned to supervise the resettlement, recorded that it was a "delicate and difficult task … removing the tribe of Indians called the Okehockings from their lodges on the banks of Ridley and Crumb creeks in the vicinity of Chester to [the] new reservation provided for them" (Weslager 1972). The group spent the warm months of the next 35 years on this tract, an unusual degree of immobility for a Lenape band, before moving westward in the face of ever-expanding European settlement. The Okehocking Indian Land Grant, located along the east fork of upper Ridley Creek (north of and adjacent to present-day West Chester Pike northwest of Ridley Creek State Park) was Pennsylvania's first Indian reservation (Ashmead 1884; Wallace 1965).

War between the United States and England in the late 1700s and again in the early 1800s and wartime shipping embargoes between the two countries caused dramatic slumps in the export market for farm products and imports of manufactured goods from Europe. The lack of European manufactured goods led to a local boom in the construction and operation of mills. Before then, mills on Crum Creek and nearby waterways were mainly grist mills and sawmills whose products were consumed locally. By the 1840s, mills producing a variety of goods sold in Philadelphia and abroad had surpassed agriculture as the dominant sector of the local economy (Berge et al. 1991). Mills were built or modified from older, smaller structures all along Crum Creek as well as Chester, Ridley, Darby, Cobbs, Wissahickon and other creeks in the area. One was on College land: Strath Haven Mills, on the Nether Providence bank of Crum Creek at the dam just upstream from the Yale Avenue-Rose Valley Road bridge. Mills upstream from the College to Martin Forest were Wallingford Mills, later known as Victoria Plush Mills, adjacent to present-day College property along Plush Mill Road and Wallingford Road; Gibbons Mill, Holtz Mill, and Lownes Mill, all at Whiskey Run where it meets Crum Creek, near where the Media trolley tracks cross Smedley Park; and Lewis Paper Mills, at the end of Paper Mill Road in Smedley Park, directly across Crum Creek from the southern end of Martin Forest (Ashmead 1884). Downstream to the mouth of Crum Creek were Leiper's Snuff-Mill, Avondale Mills, Crosby Forge,

Lapidea Mill, Davis and Culin Sawmill, Hickman's Gristmill, and Leiperville Mills (Ashmead 1884).

The most significant historic site within the Crum Woods is the site of Strath Haven Mills and the adjacent dam on Crum Creek. Operations began considerably before the heyday of water-powered industry in the area. In the summer of 1776, a local physician and entrepreneur built a gunpowder mill on the site, under a contract with the Committee of Safety (the wartime administration of the newly declared State of Pennsylvania), which required delivery of one ton of powder to the state authorities every week (Ashmead 1884). A report dated June 3, 1776 described it this way:

> *"Doctr. Robert Harris's, on Crum Creek, about three miles from Chester, begun to Work about the 23d ult. The dimensions of the Mill House 30 ft. by 20 ft., Head of Water about 2 1/2 feet fall, about 6 ft. Water Wheel 12 ft. The Shafts that Worke (Eighty Stampers of 2 3/4 by 3 3/4 Inchs & eleven ft. Length) is thirty-two ft. Long, five Mortars made of Two Inch Plank, about five foot each, one Stamper & Mortar for preparing Sulphur. Drying House, 20 ft. by 15 ft., neither floor'd nor plastered. He has received one Ton of Salt Petre and five Hundred wht of Sulphur, or thereabouts, expected to deliver one Ton of Powder on the first Inst. & the Same Quantity Weekly. The sides of the Mill House & Gable Ends of that & the Drying House being enclosed by Boards not sufficiently seasoned, am very open & must have a bad effect on the Powder, yet the Doctr is of a Different Opinion."(Pennsylvania Archives, First Series, Vol. IV., p. 709, quoted in Ashmead 1884.*)

The hastily constructed wood-frame mill was in service only until the end of the Revolutionary War (Ashmead 1884). In about 1824 its site was owned by Thomas Leiper, who built a blade mill, which was recorded in 1826 as producing about 2,400 scythes and straw-knives per year. By 1830 it had been passed to another member of the Leiper family, leased to a different operator, and converted to a paper mill. In 1843, yet another Leiper inherited the property, found a new renter, and built a cotton textile factory on the site. By then the complex covered four acres (1.6 ha) and included a stone factory and five tenement-houses. The factory and other buildings were destroyed by a fire in 1865 and lay in ruins for at least two decades (Ashmead 1884). Later, the site was used for a paper mill, where Strathmore fine art papers were first manufactured (Delaware County Planning Department 2001). Its last industrial use was during the 1920s, when part of the College's power plant occupied the site (Delaware County Planning Department 2001). A few rusted steel poles about 15 feet tall still stand widely spaced in a straight line northward through the Woods. They may have held the electrical cables connecting the power plant to campus. Extensive stone foundations and traces of a millrace cover part of the mill site, concealed from any but a close-up view by a jungle-like growth of shrubs and vines. A three-room house still exists, leased by the College as a staff residence; presumably it was built or restored in the late nineteenth or early twentieth century on the foundations of one of the original tenant houses. The Old Mill House achieved some renown 40 years ago with the publication of *The Round of the*

Year: an Almanac, an illustrated memoir of a year spent living in the house by then-professor of English Frederic Klees (Klees 1963).

Damming the Creek to provide a more stable source of water power for the mill created Strath Haven Lake. Old photographs show a much wider pool covering much of the lawn area between the present-day creek bank and Strath Haven Condominiums (Rawson et al. 1998). A detailed map of the town of Swarthmore (Anonymous 1882), published the year before it was incorporated as a borough from a part of Springfield Township, indicates a lake of about 10 acres (4.0 ha), reaching a maximum width of around 300 feet (90 m) along more than half its length of about a third of a mile (0.5 km). Keeping the lake dredged of silt accumulation was a major part of mill maintenance (Delaware County Planning Department 2001). At what point dredging was stopped is unknown, but since then the lake has been filling in and declining to its present small size. At less than 100 feet (30 m) in width, it is now not very different from natural slackwater pools elsewhere along Crum Creek. The lake provided boating and fishing opportunities for guests at the adjacent Strath Haven Inn, a 100-room luxury summer hotel built in 1892 by a wealthy Philadelphia jeweler (Morikawa and O'Donnell 1993). The inn closed in 1960 and was demolished in 1961; Strath Haven Condominiums now occupy the site. Prior to the trend of mild winters in recent decades, students at the College and residents of the town had a longstanding tradition of ice-skating on the lake.

By the 1880s, technology had caused major shifts in central Delaware County's economy and land-use patterns. Steam boiler-powered factories were turning out products more cheaply and efficiently than the old watermills. Factories were built on cheaper, flatter land near sources of cheap labor, and the mills went into rapid decline. At the same time, the growth of Philadelphia and Chester and the building of railroads and trolley lines through Swarthmore and surrounding townships caused a steep increase in land values. Farmers began subdividing their properties and selling parcels, mainly to upper-middle-class and upper-class professionals who created a new kind of residence — the elite suburban "estate" (Berge et al. 1991). Examples in the Crum Woods (all on the Nether Providence side; see Table 4) are the Castanea House, Crumwald Farm (including the Clarke House), and Hinkson's water garden. The stone and stucco ruins of this ornate garden are all that remains, in the wake of the I-476 expressway construction, of the Hinkson estate (Berge et al. 1991), known in the late nineteenth century as "Lytlecote" (Smith 1889). While farms were carved up into mini-estates, small-lot subdivisions proliferated in and around Swarthmore and other established villages and rail stops. At least one of the four College-owned houses just inside the edge of the Woods along Harvard Avenue dates from this period; the others were built later as the suburbanization phase of landscape evolution in central Delaware County continued throughout the twentieth century and into the twenty-first.

Although the Woods were apparently among the attractions that tilted the consensus of the College's founders in the early 1860s toward the present campus site from among

several contenders (Hull, undated; see Section 2.1.3), we could find no evidence that stewardship of the Woods was a specific priority for anyone at the College until the 1920s. In 1925, Samuel C. Palmer, Professor of Botany, submitted to the Board of Managers a proposal for an arboretum (Wister 1940). It captured the interest of Board member Dr. Edward Martin, Swarthmore class of 1878 (Palmer 1953: 75), who was Professor of Surgical Physiology at the University of Pennsylvania (Swarthmore College Archives, undated). The following year he and his wife Anna made a gift to the College of the Martin Forest tract (Aydelotte 1926a; Delaware County Recorder of Deeds 1926), containing probably the most intact remaining old-growth forest remnant in Delaware County (Harshberger 1904). The Board of Managers promptly appointed Dr. Martin and another Board member to the newly created Committee on the Arboretum (Aydelotte 1926b). Another key person who was intrigued by Dr. Palmer's proposal was entrepreneur Arthur Hoyt Scott, Swarthmore class of 1895. Dr. Palmer, Dr. Martin, Mr. Scott, and the College's President, Frank Aydelotte, met to discuss how Dr. Palmer's vision might be implemented (Aydelotte 1926c). The lack of a source of funds was a major hindrance, however, and no action was taken (Wister 1940). Mr. Scott died the following year. Two years later, his widow Edith Scott established and endowed the Scott Foundation as a gift to the College and memorial to her husband (B. Yagoda, personal communication).

In 1929, Mrs. Scott hired Harvard-educated landscape architect John C. Wister, of Germantown in Philadelphia, as part-time Director of the Scott Foundation (B. Yagoda, personal communication), a position he would hold for 40 years (Oppe 1979). In a report to President Aydelotte, Mr. Wister presented an inventory of every potential site on College land where conventional display gardens might be installed to arrange the new Arboretum's botanical collections. However, he also gave a list of reasons why each should be rejected. The faultfinding litany was a lead-in to what must have been a highly innovative proposal in its day:

> *If the above report has seemed disappointing in showing objections to various types of planting which have been suggested, it will only serve to emphasize the more the scheme which I am now about to recommend. The greatest assets of the college from the point of view of ownership of land are the magnificent wooded hillsides descending from the campus to Crumm [sic] Creek. … This section is heavily wooded, contains many fine trees and much interesting undergrowth. It could be developed into a wild garden of great and unusual beauty unlike anything in this section of the country at a comparatively small cost compared to display flower gardens. It would be most desirable to purchase adjoining land across the creek and up the opposite slope, to allow greater variety of treatment in closely adjoining situations with opposite aspects. Only by such purchase can the college be protected from undesirable development in the way of streets, houses, factories, water pollution, etc. (Wister 1930)*

He went on to say that "the condition of the woods while good is far from perfect," and outlined the first Crum Woods restoration and management plan, which he drew up in detail later that same year. It was implemented during the Depression, when workers

from a local unemployment relief corps removed dead wood from the forest, thinned the understory, constructed paths and rebuilt drainage ditches. The forest east of Crum Creek was divided into three sections for interplanting selected tree and shrub species among the existing vegetation. Plantings in the northern section from Wallingford Road to Alligator Rock were limited to species native to Delaware County. The central section, from Alligator Rock to the small tributary behind the Lang Music Building, was planted with rhododendrons and trees native to the rest of Pennsylvania. Species native to other parts of eastern North America were added in the section south to the railroad trestle. The goals included reducing erosion, enhancing the beauty of the forest according to the esthetic standards of the day, and diversifying learning opportunities for members of the College community studying botany (Wister 1940).

Mr. Wister had a different plan for the area south of the railroad trestle, in and around the Crum Meadow. He proposed planting trees and shrubs from the temperate zone of the entire world, arranged in "botanical sequence" according to theories of the time of the geological age of each lineage's origin. His plan for the 8.5-acre (3.4-ha) Meadow itself, which he named Palmer Meadow in honor of the professor who conceived the arboretum, was "a great garden of flowering trees, shrubs and herbaceous plants in much greater variety than can be planted in any one place on the campus" (Wister 1940). This vision was never fulfilled, but about 2.5 acres (1.0 ha) of low slopes and floodplain along the Meadow's northeastern perimeter eventually became home to the Frorer Holly Collection, donated to the Arboretum in 1973 by James R. Frorer, Swarthmore class of 1915. A miniature version of his vision for the Meadow is Wister's Garden, created and maintained by Mr. Wister and later, after marrying at age 73, with help from his wife Gertrude. It occupies more than an acre (0.4 ha) of the slope between Crum Creek and 735 Harvard Avenue, the house built by the College into which Mr. Wister moved from Germantown in 1945 and in which he and Mrs. Wister lived until his death in 1982 and hers in 1999.

The next management plan for the Woods, by forester Ronald Langford (1974, 1980), focused on sawtimber stand improvement. It is utterly inconsistent with management priorities today. Fortunately, little was done to implement the plan and the College did not turn to timber sales as a supplemental source of income as suggested by Mr. Langford. The most recent plan, prepared by Andropogon Associates (1988), usefully and aptly concentrated on stormwater runoff erosion problems and potential solutions. Other recommendations regarding esthetics and invasive introduced species were progressive, but they lacked the details required for implementation and were not focused on specific areas within the woods. Neither Langford nor Andropogon were hired to address the educational uses or the specific pedagogical and research assets of the Crum Woods. Nearly all of the Arboretum's work since Mr. Wister's tenure as Director has focused on the campus plantings. Work in the Woods has mainly involved maintaining the stability and safety of the more heavily used trails and adjacent steep slopes. However, some of the Arboretum's activities on campus have benefited the Woods. Partly in fulfillment of the Andropogon plan, the Arboretum has undertaken

several major efforts to control runoff from campus (see Section 2.2.1.2: Stormwater management), which has been a perennial cause of major erosion and gullying in the Woods, particularly on the slopes between the railroad trestle and DuPont parking lot. More recently, the Arboretum has also begun removing Norway maple and other invasive species that are crowding out the remaining native plants in some parts of the Campus Woods.

The earliest known scientific use of the Crum Woods pre-dated the College's acquisition of the particular part of the Woods that was the subject of the study. In a 1904 publication titled "A phyto-geographic sketch of extreme southeastern Pennsylvania," John W. Harshberger, Professor of Botany at the University of Pennsylvania, used the present-day Martin Forest tract as one of several models for piecing together the species composition and general appearance of the region's forests before European settlement. The section on forests begins:

> *Originally the forest covered most of the surface of southeast Pennsylvania. In some places, notably on the Wissahickon creek within the confines of Fairmount Park and in areas on Crum creek, the primeval forest still remains. Mr. J. Howard Lewis, Sr., and his progenitors have preserved inviolate a large tract of timber along Crum creek, while the surrounding country settled by patent in 1681 and 1682 has been cleared of its timber for many years. A study of such preserves shows the character of the original forest. The dominant and secondary forest trees grow on precipitous rocks, on declivitous hillsides, on the plateau surfaces … [and] on the creek bottoms … where the trees reach their largest size …* [p. 141]

One area of bottomland on the Martin tract is still the place where trees reach their largest size in any part of the Crum Woods. Tuliptree and American beech dominate a remnant old-growth forest stand, together with boxelder, red maple, sugar maple, bitternut hickory and green ash, a rich understory that includes witch-hazel, spicebush and bladdernut, and a lush growth of mostly spring-flowering herbaceous plants, including wild-ginger, blue cohosh, spring-beauty, Dutchman's-breeches, yellow trout-lily, Virginia waterleaf, dwarf ginseng, mayapple, skunk-cabbage, bellwort, downy yellow violet, and common blue violet. Sixteen of the tuliptrees are giants, with trunks up to 5 ft. 7.7 in. (172 cm) in diameter and heights over 100 feet (30 m). Bordered on one side by a wild reach of Crum Creek and on the other by a half-circle of steep slopes where jagged, massive boulders and cliffs form breaks in a dense cover of oak, eastern hemlock and mountain-laurel, this old-growth stand is an extraordinary piece of living history.

The arrival of Western civilization has been more like a geologic force than merely a population shift in one species. Besides cutting nearly all of the forest and converting large areas to crops and pasture, Europeans introduced new microbes, animals and plants and exploited the native biota far more intensively than the previous human occupants had done. Industrialization since about 150 years ago has accelerated the pace of change, adding the filling of wetlands, urban sprawl, highway construction, and

the release of nutrients, acidifying compounds, pesticides and other toxins into surface waters, rain, groundwater and soil. The results have been dramatic. So far, 71 animal species and subspecies are known to have been eliminated across the state of Pennsylvania in the few groups that have been studied (Latham 2002). These include the wolf and mountain lion, the only top predators remaining other than humans after the earlier human-caused wave of extinctions. Across Pennsylvania, at least 83 native vascular plants have been extirpated and thousands of non-natives have been introduced, including 1,281 plant species that have become naturalized residents, more than 37% of the total vascular flora of the state (Rhoads and Block 2000). Numerous introduced species have had a destructive impact on native organisms, including, in the Crum Woods, Norway maple, *Acer platanoides*, hemlock woolly adelgid, *Adelges tsugae*, chestnut blight fungus, *Cryphonectria parasitica*, dogwood anthracnose fungus, *Discula destructiva*, English ivy, *Hedera helix*, gypsy moth, *Lymantria dispar*, beech bark disease fungi, *Nectria coccinea* var. *faginata, N. galligena*, beech bark scale, *Cryptococcus fagi*, Dutch elm disease fungus, *Ophiostoma ulmi*, and Japanese knotweed, *Polygonum cuspidatum*.

1.2 COMMUNITY AND ECOSYSTEM DIVERSITY

Good stewardship must be based on a thorough inventory of the land and its biota, and on a scientific understanding of their past, present and likely future transformations. Ecologists have noted for centuries that species tend to sort themselves out in a pattern of roughly repeated assemblages across the landscape. In this document, the indigenous plant communities of the Crum Woods are classified according to *Terrestrial and Palustrine Plant Communities of Pennsylvania* (Fike 1999). In this context, **terrestrial** corresponds closely with **upland** and **palustrine** is synonymous with **wetland**. The other major group of communities in the Crum Woods is **aquatic**. For aquatic community classification, an older source is used (Smith 1991), which has been updated and supplanted for land-surface communities (Fike 1999) but not for aquatic communities. A committee convened by the Pennsylvania Natural Diversity Inventory is currently in the process of refining aquatic community classification (Latham 2002).

One other fundamental distinction is made at the highest level of the classification scheme presented in this report: **indigenous** communities are separated from those that are **culturally modified**. In reality there is a continuum between the two categories and certainly no community in the Crum Woods has escaped some degree of cultural modification. Communities are classified as culturally modified if they are dominated by species not native to this region or if they have been drastically changed by recent cultural practices such as regular mowing.

The following descriptions are in telegraphic form. The name of each community type is marked by a bullet and the lines beneath are: (1) dominant canopy species[2] and noteworthy subordinate species; (2) ecology, including a model of expected community dynamics; (3) comments on significance as habitat for animal life; (4) general distribution in the Crum Woods. Plant communities of the Crum Woods are mapped in Figures 4 and 5; mapping methodology is summarized in Appendix N.

1.2.1 Forests and woodlands

Forests are tree-dominated communities in which the leaf canopy is closed or nearly closed and the majority of tree crowns are overlapping, typically with between 60% and 100% tree cover. **Woodlands** have between 20% and 60% tree cover.

1.2.1.1 Indigenous upland forests and woodlands

- **Dry oak-heath forest**
  — Chestnut oak, *Quercus montana*, is the signature species. Other dominants: white oak, *Q. alba*, scarlet oak, *Q. coccinea*, northern red oak, *Q. rubra*, black oak, *Q. velutina*, blackgum, *Nyssa sylvatica*, red maple, *Acer rubrum*. Understory characterized by often-dense stands of mountain-laurel, *Kalmia latifolia*, lowbush blueberry, *Vaccinium pallidum*, maple-leaved viburnum, *Viburnum acerifolium*.
  — On dry to moderately dry, acidic, shallow soils usually on steep slopes. Oak diversity and dominance most likely a legacy of Native American burning practices over centuries or thousands of years. Ordinarily requires infrequent ground-fires for long-term persistence on a scale of centuries. Can be maintained by planting oaks and removing fast-growing competitors in natural canopy gaps created by the death of old trees.
  — Intermediate to high value for wildlife.
  — West-facing slopes around Alligator Rock; Southern Red Oak Forest.

- **Dry oak-mixed hardwood forest**
  — White oak, *Quercus alba*, scarlet oak, *Q. coccinea*, southern red oak, *Q. falcata*, northern red oak, *Q. rubra*, black oak, *Q. velutina*, blackgum, *Nyssa sylvatica*, white ash, *Fraxinus americana*, red maple, *Acer rubrum*, mockernut hickory, *Carya tomentosa*. Common understory species: flowering dogwood, *Cornus florida*, bladdernut, *Staphylea trifolia*, witch-hazel, *Hamamelis virginiana*, maple-leaved viburnum, *Viburnum acerifolium*, blackhaw, *V. prunifolium*.
  — On moderately dry to moist, moderately acidic soils. Oak diversity and dominance most likely a legacy of Native American burning practices over

[2] Dominant species are those that exert strong control over environmental conditions by virtue of their population density or majority share of total ecosystem biomass. Canopy refers to the leaves of the tallest plants in a community. Thus the dominant canopy species in a forest, for example, are the most common tree species. Uncommon trees, even though they are also in the canopy, are termed subordinate, as are all tree seedlings and saplings, shrubs, and other low plants that live in the shade beneath the canopy.

centuries or thousands of years. Ordinarily requires infrequent ground-fires for long-term persistence on a scale of centuries. Can be maintained by planting oaks and removing fast-growing competitors in natural canopy gaps created by the death of old trees.
— Intermediate to high value for wildlife.
— Northwest-facing slopes of Elm Avenue Cove; most of Southern Red Oak Forest; Hogback Knoll (west side of creek under trestle).

- **Hemlock (white pine)-red oak-mixed hardwood forest**
  — Eastern hemlock, *Tsuga canadensis*, northern red oak, *Quercus rubra*, American beech, *Fagus grandifolia*, blackgum, *Nyssa sylvatica*, red maple, *Acer rubrum*.
  — On moist or moderately moist soils, usually on steep slopes. Threatened by hemlock woolly adelgid aphid. Will be replaced by red oak-mixed hardwood forest if adelgids are unchecked.
  — High value for wildlife; conifers add more effective cover year-round for animals that are vulnerable to visually orienting predators.
  — Mostly northwest-facing mid- and lower slopes on east side of gorge, including Martin Forest (Smedley Park tract).

- **Red oak-mixed hardwood forest**
  — Northern red oak, *Quercus rubra* with a mixture of other species including American beech, *Fagus grandifolia*, blackgum, *Nyssa sylvatica*, red maple, *Acer rubrum*, tuliptree, *Liriodendron tulipifera*, white ash, *Fraxinus americana*, bitternut hickory, *Carya cordiformis*, mockernut hickory, *C. tomentosa*, Common understory species: witch-hazel, *Hamamelis virginiana*, American hornbeam, *Carpinus caroliniana*, hop-hornbeam, *Ostrya virginiana*, southern arrowwood, *Viburnum dentatum*, pawpaw, *Asimina triloba*, spicebush, *Lindera benzoin*.
  — On moist or moderately moist soils. Perhaps longer-persisting in the absence of fire than other oak-dominated communities, but infrequent ground-fires are still a factor in its long-term persistence. Will slowly succeed to tuliptree-beech-maple forest without fire or assisted oak regeneration.
  — High value for wildlife; tends to have a denser understory shrub cover than types described above.
  — Scattered in various locations along slopes of gorge.

- **Tuliptree-beech-maple forest**
  — Tuliptree, *Liriodendron tulipifera* and American beech, *Fagus grandifolia*, with a mixture of other species including black cherry, *Prunus serotina*, northern red oak, *Quercus rubra*, blackgum, *Nyssa sylvatica*, red maple, *Acer rubrum*, sugar maple, *A. saccharum*, white ash, *Fraxinus americana*, bitternut hickory, *Carya cordiformis*, mockernut hickory, *C. tomentosa*, sweet birch, *Betula lenta*. Characterized by the highest diversity of ground-layer herbaceous species, especially in the spring, including may-apple, *Podophyllum peltatum*, red trillium, *Trillium erectum*, white trillium, *T. grandiflorum*, Dutchman's-breeches, *Dicentra cucullaria*, spring-beauty,

Claytonia virginica.
— On moist, fairly deep, not strongly acidic soils, on mid- to lower slopes. More vulnerable to colonization by invasive species than types described above. Should be self-sustaining with little management except for control of invasive plants. Beech bark scale and beech bark disease could become a problem in the future.
— High value for wildlife. Tends to have the densest understory shrub cover of any upland forest type in the Crum Woods, utilized by many animal species as cover and an important food source.
— Martin Forest bottomland; Elm Avenue Cove; lower slopes on west side of gorge.

1.2.1.2 Indigenous swamp and floodplain forests and woodlands

- **Sycamore-(river birch)-boxelder floodplain forest/woodland**
  — American sycamore, *Platanus occidentalis*, boxelder, *Acer negundo*, silver maple, *A. saccharinum*, green ash/red ash, *Fraxinus pennsylvanica*. Dense understory includes include silky dogwood, *Cornus amomum*, poison-ivy, *Toxicodendron radicans*, frost grape, *Vitis riparia* and the invasives Japanese knotweed, *Polygonum cuspidatum*, mile-a-minute, *P. perfoliatum*, Japanese honeysuckle, *Lonicera japonica*, Amur honeysuckle, *L. maackii*, border privet, *Ligustrum obtusifolium*, multiflora rose, *Rosa multiflora*.
  — On land affected by seasonal flooding along mid-sized streams.
  — Moderate to high value for wildlife.
  — Most of the flats along Crum Creek.

- **Red maple-mixed shrub palustrine woodland**
  — Red maple, *Acer rubrum* with scattered black willow, *Salix nigra*. Dense understory includes silky dogwood, *Cornus amomum*, southern arrowwood, *Viburnum dentatum*, spicebush, *Lindera benzoin*, American hornbeam, *Carpinus caroliniana* and the invasive shrubs Amur honeysuckle, *Lonicera maackii*, border privet, *Ligustrum obtusifolium*, multiflora rose, *Rosa multiflora*. Variant at Skunk-cabbage Hollow has a regionally significant mix of unusual tree species, including balsam poplar, *Populus balsamifera*, honeylocust, *Gleditsia triacanthos*, black walnut, *Juglans nigra*.
  — On mineral soil (not peat), somewhat acidic to circumneutral, with a thin layer of muck. Self-sustaining or could fluctuate back and forth with red maple-mixed shrub palustrine woodland or mixed forb marsh, due to trees' shallow rooting systems leading to frequent toppling.
  — High value for wildlife. Critical for wetland specialists and utilized by many of the same species that occur in surrounding upland habitats.
  — Oxbow Swamp; Skunk-cabbage Hollow.

1.2.1.3 Culturally modified forests and woodlands

- **Forest/woodland with strong presence of introduced species**
- **Wet forest/woodland with strong presence of introduced species**

  — Norway maple, *Acer platanoides*, black locust, *Robinia pseudoacacia*, tuliptree, *Liriodendron tulipifera*, white ash, *Fraxinus americana* with introduced species abundant as canopy subordinates or in subcanopy.
  — Often even-aged, which suppresses understory and ground-layer growth unless canopy trees are thinned. Stand thinning and planting of native tree and shrub species is desirable to eliminate invasive species at a stage of growth when least costly and to hasten progression toward mature forest. Low diversity will persist for a very long time without management. These communities have instructional value as site for research on effects of invasive species. However, they export invasive species' seeds and thus threaten the health and integrity of nearby Natural Areas. Black locust-dominated stands are limited in extent and black locust will not spread into existing forest as long as the canopy is intact. Thus there is no need to spend resources on its removal, unless it invades upland meadow dominated by native species. Norway maple, by contrast, spreads aggressively into intact forest and should be removed. Highest priority sites for Norway maple removal are Natural Areas and their immediate surroundings.
  — Low to very low value for wildlife. Tends to have extremely low plant species diversity and often sparse to completely barren understory and ground layers.
  — Scattered mainly along west side of gorge.

- **Conifer plantation/planted forest**
  — Norway spruce, *Picea abies*, red pine, *Pinus resinosa*, eastern white pine, *Pinus strobus*, eastern hemlock, *Tsuga canadensis* and various broadleaf tree species. Understory highly variable, but introduced species usually abundant.
  — Will persist for many years but eventually planted conifers will age and die. Invasive species should be monitored, removed where spreading, and native tree and shrub species planted to help check further invasion.
  — Low to intermediate value for wildlife. Conifers provide effective year-round cover for animals that are vulnerable to visually-orienting predators, but understory and ground layers are impoverished or nonexistent and overall species diversity is low.
  — Mainly southeast and north of Castanea House on Swarthmore Farm Plateau.

- **Mowed woodland**
- **Wet mowed woodland**
  — Various tree species. Ground layer of mowed turf.
  — Maintained by mowing and by the planting of saplings to replace fallen trees.
  — Very low to low value for most wildlife species.
  — Along Crum Creek below Strath Haven Condominiums.

1.2.1.4 Forest and woodland understory vegetation

The structure and species composition of the shrub and ground layers are only loosely correlated with community type, especially in the environs of old port cities such as Philadelphia, where introduced invasive species commonly surpass natives in abundance. Ground-layer vegetation is classified across all plant communities and land cover types, including forests and woodlands in six categories (those that occur in forests and woodlands are mapped in Figures 6 and 7):

- **Dense/intermediate/sparse native shrub layer**
  — Shrub layer estimated to be at least 80% native species by proportion of shrub biomass.

- **Dense/intermediate/sparse introduced shrub layer**
  — Shrub layer estimated to be at least 80% introduced species by proportion of shrub biomass.

- **Dense/intermediate/sparse mixed shrub layer**
  — Shrub layer a mixture of native and introduced species that does not meet either of the above criteria.

- **All-herbaceous ground layer (meadow)**
  — See "upland meadow" under 1.2.2.2, below.

- **Turf**
  — See "upland/wet mowed turf" under 1.2.2.2, below.

- **Shrub and ground layers absent**
  — Occurs beneath monospecific stands of Norway maple, *Acer platanoides*, or in dense conifer plantations.

Well developed shrub and ground layers of mostly native species have become quite rare in forests of our region. Their presence signifies an exceptionally intact community whose preservation as a Natural Area is worthy of considerable effort. In general, shrub layer density and species diversity have strong positive correlations with wildlife habitat value, particularly for birds and mammals. Tall, dense meadow vegetation also provides rich habitat for many species of wildlife. Meadows dominated by native plant species are scarce in the region and therefore add to community diversity and accommodate an "underserved" group of species, many of which are rare or becoming so. The wildlife habitat value of turf is essentially nil.

1.2.2 Shrublands and herbaceous communities

1.2.2.1 Indigenous swamp, marsh and floodplain shrub and herbaceous communities

- **Black willow scrub/shrub wetland**
  — Black willow, *Salix nigra*, smooth alder, *Alnus serrulata*, silky dogwood, *Cornus amomum*.
  — Maintained by prolonged inundation or flood- and ice-scouring. Occurrences along Crum Creek expected to persist without intervention. Occurrence at Oxbow Swamp could be subject to invasion by common reed, *Phragmites australis*, multiflora rose, *Rosa multiflora*, Japanese honeysuckle, *Lonicera japonica*, Amur honeysuckle, *L. maackii*, border privet, *Ligustrum obtusifolium*.
  — Intermediate to high value for wildlife. Critical for many wetland-specialist species.
  — Oxbow Swamp; stony islands and shores along Crum Creek.

- **Mixed forb marsh**
  — Skunk-cabbage, *Symplocarpus foetidus*, smartweeds and tearthumbs, *Polygonum* spp., docks, *Rumex* spp., rushes, *Juncus* spp., beggar-ticks, *Bidens* spp., spotted touch-me-not, *Impatiens capensis*, sensitive fern, *Onoclea sensibilis*, arrowhead, *Sagittaria latifolia*, tussock sedge, *Carex stricta*, rice cutgrass, *Leersia oryzoides*, joe-pye-weeds, *Eupatorium* spp.
  — Maintained by prolonged inundation. Subject to invasion and impoverishment by common reed, *Phragmites australis*, purple loosestrife, *Lythrum salicaria*, reed canary grass, *Phalaris arundinacea*, Japanese honeysuckle, *Lonicera japonica*, Amur honeysuckle, *L. maackii*, border privet, *Ligustrum obtusifolium*.
  — High to very high value for wildlife. Critical for many wetland-specialist species.
  — Oxbow Swamp; Skunk-cabbage Hollow.

1.2.2.2 Culturally modified shrub and herbaceous vegetation

- **Upland/wet successional thicket**
  — Mixture of native and introduced shrub, woody vine and herbaceous species usually with scattered small trees. Native shrubs, lianas and herbs: blackberries, *Rubus* spp., black raspberry, *R. occidentalis*, boxelder, *Acer negundo*, poison-ivy, *Toxicodendron radicans*, sassafras, *Sassafras albidum*, black cherry, *Prunus serotina*, Virginia-creeper, *Parthenocissus quinquefolia*, grapes, *Vitis* spp., spicebush, *Lindera benzoin*, pokeweed, *Phytolacca americana*, southern arrowwood, *Viburnum dentatum*, silky dogwood, *Cornus amomum*. Introduced shrubs, lianas and herbs: multiflora rose, *Rosa multiflora*, Japanese honeysuckle, *Lonicera japonica*, Amur honeysuckle, *L. maackii*, border privet, *Ligustrum obtusifolium*, oriental bittersweet, *Celastrus orbiculatus*, wineberry, *Rubus phoenicolasius*, Japanese angelica-tree, *Aralia*

elata, tree-of-heaven, *Ailanthus altissima*, mile-a-minute, *Polygonum perfoliatum*.
— Usually also includes scattered small trees. Occurs either where forest stand has been removed by cutting or natural disturbance or where cropland or turf has been abandoned. Where formerly cropland or turf, introduced invasive species usually dominate. Expected to succeed to woodland and forest in 10 to 30 years. Woodland or forest composition most likely will reflect current composition of scattered small trees.
— Low to high value for wildlife, depending on diversity and density.
— Scattered along edges of meadows and mowed areas west of the gorge.

- **Landscaped area**
  — Mixture of herbaceous plants kept short by mowing multiple times during the growing season and mostly planted trees and shrubs. Dominated by cool-season[3] introduced grass species (usually fescues, *Festuca* spp., ryegrasses, *Lolium* spp., bluegrasses, *Poa* spp.) and shade or specimen trees, often of introduced species.
  — Maintained artificially by mowing, weeding, pruning, planting and in some cases by application of pesticides.
  — Low value for wildlife, although plantings are sometimes designed to provide food and cover for birds and butterflies, and bird feeders, vegetable gardens and human or pet food waste attract birds, squirrels, rabbits, woodchucks, white-tailed deer, raccoons and opossums.
  — Around residences in Crum Woods.

- **Herb-dominated old field/road cut**
  — Grasses and other, often invasive, herbaceous plants interspersed with woody vines, shrubs and trees. Characteristic species include crownvetch, *Coronilla varia*, little bluestem, *Schizachyrium scoparium*, black locust, *Robinia pseudoacacia*.
  — Plants are slow-growing because upper layer of soil has been removed and the remaining soil is typically low in mineral nutrients. Restricted to species that are tolerant of low-nutrient situations (e.g., little bluestem) or those that host bacterial symbionts able to convert atmospheric nitrogen into usable mineral form (e.g., crownvetch, black locust). Eventually will build up organic matter and soil nutrient concentrations, allowing invasion by other tree species.
  — Low value for wildlife, partly due to low primary (plant) productivity.
  — West side of Swarthmore Farm Plateau.

- **Upland/wet mowed turf**
  — Herbaceous plants kept short by mowing multiple times during the growing season. Dominated by cool-season introduced grass species (usually fescues, *Festuca* spp., ryegrasses, *Lolium* spp., bluegrasses, *Poa* spp.), often interspersed

[3] Cool-season grasses possess the most common photosynthetic pathway, known as C3 photosynthesis; new leaves emerge in late winter or early spring and they generally flower and set fruit in spring or early summer.

with introduced warm-season[4] annual grass species (e.g., crabgrasses, *Digitaria ischaemum, D. sanguinaria*, Japanese stilt grass, *Microstegium vimineum*, foxtails, *Setaria faberi, S. pumila*).
— Maintained with costly, frequent management using fossil-fuel-powered machinery and sometimes chemical herbicides. Perpetrates the most severe edge effects where adjacent to forest.
— Virtually no value for wildlife.
— Crum Meadow; area along Crum Creek at Strath Haven Condominiums and Yale Avenue; parts of petroleum pipeline right-of-way; lawns near Old Mill House, composting facility, Arboretum nursery, Crumwald Farm (Clarke House and environs).

- **Upland meadow**
  — Mixture of tall and short grasses and forbs (herbaceous vascular plants other than grasses). Occurs in areas mowed once per year or less, in most cases during the dormant season. Usually includes some coverage by native warm-season perennial grass species (e.g., little bluestem, *Schizachyrium scoparium*, Indian grass, *Sorghastrum nutans*, big bluestem, *Andropogon gerardii*, broomsedge, *A. virginicus*) and members of the composite family (e.g., goldenrods, *Solidago* spp. and *Euthamia* spp., asters, *Aster* spp., joe-pye-weeds and snakeroots, *Eupatorium* spp.).
  — Prehistorically and historically much more prevalent in the region. Originally maintained by Native Americans solely by burning, with average fire return intervals of perhaps 5 to 10 years. More recently maintained either by burning or by mowing once per year or less often, usually during the dormant season.
  — High to very high value for wildlife, depending on density, species diversity, and structural complexity (diversity of species' functional types and sizes). Meadow and grassland are much reduced from their former extent in the region and native species dependent on them are in decline or have been extirpated.
  — Not present in the study area but included here because of its high potential value and advantages for replacing upland turf in some areas.

- **Wet meadow**
  — Goldenrods, *Solidago* spp. and *Euthamia* spp., asters, *Aster* spp., joe-pye-weeds and snakeroots, *Eupatorium* spp., Japanese plumegrass, *Miscanthus sinensis*.
  — Prehistorically and historically much more prevalent in the region. Originally maintained by Native Americans solely by burning, with return intervals of perhaps 5 to 10 years. More recently maintained either by burning or by mowing once per year or less often, usually during the dormant season.
  — High to very high value for wildlife, depending on density, species diversity, and structural complexity (diversity of species' functional types and sizes). Meadow and grassland are much reduced from their former extent in the region

[4] Warm-season grasses possess modified leaf anatomy and an unusual photosynthetic pathway, C4 photosynthesis; their emergence is often delayed until late spring or early summer and they generally flower and set fruit in late summer or fall.

and native species dependent on them are in decline or have been extirpated. Introduced grass species is likely to spread further unless steps are taken to contain or remove it.
— Small area between Strath Haven Condominiums and Crum Creek near forest in front of Cratsley House.

1.2.3 Aquatic communities

1.2.3.1 Crum Creek

- **Low-gradient clearwater creek**
  — American eel, *Anguilla rostrata*, swallowtail shiner, *Notropis procne*, white sucker, *Catostomus commersoni*, catfishes, *Ameirus* spp., sunfishes, *Lepomis* spp., largemouth bass, *Micropterus salmoides*.
  — Stream with a fall of less than 1 ft. per mi. (0.2 m km^{-1}). Water flow is sluggish. Silt and muck-covered bottom. Few aquatic vascular plants owing to high water turbidity and silt deposition. Main energy source is decaying plant matter from floodplain and upland vegetation.
  — Scarcity of aquatic plants and rocks provides scant substrate for algae and animals that require attachment sites.
  — Strath Haven Lake (the slackwater section of Crum Creek behind the dam near Yale Avenue). Old photographs and maps show a much wider pool covering much of the lawn area below the present-day Strath Haven condominiums (Anonymous 1882; Rawson et al. 1998). Now nothing more than a slightly wider section of Crum Creek, extending approximately 0.6 mi. (1 km) upstream from the dam during periods of average flow to around the lower end of Crum Meadow.

- **Medium-gradient clearwater creek**
  — Aquatic beetles, *Stenelmis* spp. and others, dragonflies and damselflies, Gomphidae, American eel, *Anguilla rostrata*, satinfish shiner, *Cyprinella analostana*, spotfin shiner, *Cyprinella spiloptera*, common shiner, *Luxilus chrysocephalus*, fallfish, *Semotilus corporalis*, banded killifish, *Fundulus diaphanus*, tessellated darter, *Etheostoma olmstedi*, common snapping turtle, *Chelydra serpentina*, northern water snake, *Nerodia sipedon*.
  — Stream with a fall of between 1 and 10 ft. per mi. (0.2 to 2.0 m km^{-1}). Water flow intermediate in velocity. Mostly muddy bottom interspersed with scattered riffles and rapids over short stretches of rocky bottom and artificial structures. Some endogenous primary production by algae and vascular aquatic plants, but decaying plant matter from floodplain and upland vegetation also an important energy source.
  — Rocky areas provide substrate for algae and animals that require attachment sites and cover from strong currents and predators.
  — About 1 mi. (1.6 km) of Crum Creek above Strath Haven Lake to the limit of College property (Wallingford Road-Plush Mill Road bridge) and 0.5 mi. (0.8 km)

along Martin Forest, including low dam beneath railroad trestle at petroleum pipeline crossing and exposed pipeline crossing and artificially created rock base (Cushman and Lowe 1971) below DuPont Science Building.

1.2.3.2 Other streams

- **High-gradient clearwater creek**
  — Mayflies, *Ephemerella* spp. and others, caddisflies, *Hydropsyche* spp. and others, crayfish, *Orconectes limosus*, leeches, Hirudinea, cutlips minnow, *Exoglossum maxillingua*, blacknose dace, *Rhinichthys atratulus*, northern dusky salamander, *Desmognathus fuscus*, redback salamander, *Plethodon cinereus*.
  — Rapidly flowing but small perennial first-order streams with a fall of greater than 10 ft. per mi. (0.2 to 2.0 m km^{-1}). Bottom a mixture of rocks, gravel, sand and silt. Flows fluctuate widely with rain and drought. Small amount of primary production by algae; decomposers also derive energy from decaying upland and wetland plant parts.
  — Rocks provide substrate for algae and animals that require attachment sites and cover from strong currents and predators.
  — Four occurrences — Dicks Run, tributary near Elm Avenue, tributary near Clothier Field, and tributary in Martin Forest — totaling 0.8 stream miles (1.3 km) through College land.

- **High-gradient ephemeral/intermittent creek**
  — Crayfish, *Orconectes limosus*, in lower reaches; otherwise little or no aquatic life.
  — Streams with watersheds of 15 acres (6 ha) or less that flow only after rains.
  — Little or no significance as habitat for animal life.
  — Half-dozen or more occurrences, including two in Martin Forest.

1.3 ORGANISMAL DIVERSITY

With few exceptions, there is little documentation of what species live in the Crum Woods, but it is possible to estimate how many species are likely to be present for many taxonomic groups (Appendix E). The best-documented major taxa of organisms are vascular land plants (Appendix F) and birds (Appendix G). Vascular land plants are the chief primary producers for the Crum Woods' aquatic as well as terrestrial and palustrine ecosystems, and their diversity correlates roughly with the diversity of animals, fungi and other microorganisms.

The Crum Woods provide some of the last remaining habitat in central Delaware County for resident forest-interior wildlife species. They are highly vulnerable because they are sensitive to forest fragmentation. The best known animals in this category are birds, including red-eyed vireo, wood thrush, ovenbird, great crested flycatcher, and eastern wood-pewee, but native species of mammals, turtles, snakes, salamanders, fish,

butterflies, moths, and other major groups are also known to require large, unbroken blocks of forest for survival (Whitcomb et al. 1981; Hollingsworth 1988; Temple and Cary 1988; Yahner 1992, 1997, 1998; Robbins et al. 1989; Porzeluzi et al. 1993; Hoover et al. 1995; Robinson et al. 1995; Gibbs 1998; O'Connell et al. 1998, 2000). Observations over the last 20 years show a trend in some of these species of local population decline (J. Williams, personal communication). Many species require blocks of forest that are larger than the present size of the Crum Woods, for example, scarlet tanager, Canada warbler, and gray fox; these species have not been seen raising offspring in the Crum Woods recently and are assumed no longer to be residents.

Other regionally noteworthy birds of the 61 species that have been seen nesting and raising offspring in the Crum Woods (Appendix G) include wood duck, great horned owl, screech owl, red-tailed hawk, pileated woodpecker, rose-breasted grosbeak, orchard oriole, Baltimore oriole, and blue-gray gnatcatcher. As an island of natural habitat in a sea of suburbia, the Crum Woods are also a bountiful migratory bird stopover site, especially the wetland-floodplain area below Crum Ledge known as Skunk-cabbage Hollow (J. Williams, personal communication). Besides the ubiquitous gray squirrel, chipmunk and eastern cottontail, less conspicuous mammals are known to live and raise offspring in the Crum Woods, including opossum, short-tailed shrew, eastern mole, little brown bat, big brown bat, red bat, woodchuck, southern flying squirrel, white-footed mouse, meadow vole, pine vole, meadow jumping mouse, raccoon, red fox, skunk, and white-tailed deer. Other spectacular but seldom-seen fauna living in the Woods include eight species of giant native silkmoths: promethea, cecropia, luna, polyphemus, io, imperial, tuliptree silkmoth, and royal walnut moth, the latter known in the larval stage as the hickory horned devil (T. Valente, personal communication).

The majority of animal species living in the Crum Woods' forests, woodlands, shrublands, marshes and meadows are rarely noticed, except by students in field biology classes. They are generally small and they live in the forest canopy, other parts of living plants, rotting logs, seasonally ponded water, and soil. Most of the animal species are insects; major groups include bristletails, cockroaches, beetles, earwigs, "true" flies, mayflies, wheel bugs, spittlebugs, cicadas, plant bugs, leafhoppers, whiteflies, aphids, mealybugs, scales, plant lice, sawflies, wasps, bees, ants, termites, butterflies, moths, skippers, mantids, scorpionflies, hangingflies, lacewings, ant-lions, dragonflies, damselflies, grasshoppers, crickets, katydids, walking-sticks, parasitic lice, booklice, barklice, fleas, twisted-wing insects, thrips, and silverfish. Many other animal groups are represented also, including mites, ticks, spiders, daddy-longlegs, pseudoscorpions, pillbugs, wood-lice, springtails, entotrophs, proturans, centipedes, pauropods, symphylans, terrestrial snails, slugs, millipedes, roundworms, tapeworms, and flukes (see Appendix E).

Crum Creek and its tributaries provide homes to a diverse set of aquatic organisms, which includes diatoms, leeches, tubifex worms, scuds, crayfishes, dobsonflies,

stoneflies, a freshwater sponge, beetles, "true" flies, mayflies, water-striders, dragonflies, damselflies, caddisflies, aquatic snails, fingernail clams, water mites, copepods, gastrotrichs, roundworms, flatworms, and green algae (see Appendix E for data sources). Fish species living in the creek include American eel, satinfish shiner, spotfin shiner, cutlips minnow, common shiner, swallowtail shiner, blacknose dace, creek chub, fallfish, white sucker, white catfish, yellow bullhead, brown bullhead, margined madtom, banded killifish, mummichog, redbreast sunfish, green sunfish, pumpkinseed, bluegill, largemouth bass, and tessellated darter (see Appendix E for data sources). Several other resident vertebrate species spend at least part of their lives in the creeks, including wood duck, mallard, belted kingfisher, northern dusky salamander, northern two-lined salamander, northern longtail salamander, redback salamander, northern red salamander, northern spring peeper, bullfrog, green frog, pickerel frog, wood frog, common snapping turtle, common musk turtle, and northern water snake (Williams et al. 1999; R. K. Conant, personal communication).

1.4 EXISTING USES

1.4.1 Primary uses

Primary uses are those that relate directly to the fulfillment of the College's mission. They involve Swarthmore College students and the education process, either directly or indirectly. At present, there is little conflict among these uses but the pressures for education-related use are increasing and the potential is strong for future conflicts. If inadvertent competition is to be avoided, teaching, research, and other non-casual uses must be coordinated systematically by a member of the college.

1.4.1.1 Teaching and student independent study

Swarthmore professors have a long history of teaching in the Crum Woods, in all probability dating back to the College's first academic year, 1869-70, when botany and geology were taught to all students in a multi-year course called Natural Sciences (Rawson 1989). Botany was part of the curriculum continuously through 1974-75 and has been offered intermittently (as Systematic Botany) since then, geology has been taught at irregular intervals (currently as Principles of the Earth Sciences), and ecology has been offered every year but one from 1960-61 to the present. In a 2002 survey, alumni reported taking classes and carrying out class assignments in the Woods in an ever-increasing roster of courses since the mid-twentieth century (see Appendix A, Table A3).

Currently, at least 35 professors in 12 departments use or have recently used the Crum Woods and Crum Creek in their classes and for class assignments (see Appendices A, B and C). A partial list of courses taught from 1998 through 2003 in which at least some

class meetings, laboratory exercises, or assignments took place in the Woods is given on Table 2.

The Crum Woods and Crum Creek serve in several courses and seminars each year as the prime focal point for hands-on learning — the main "laboratory" or "studio" for work done in class or the principal (or exclusive) venue for students' independent projects. Examples include Behavioral Ecology, Ecology, Field Ornithology, Field Studies in Animal Behavior and Natural History, Forest Ecology, Plant Competition, Systematic Botany, Water Quality and Pollution Control, and Writing Nature. Organismal and Population Biology, among the handful of classes whose enrollment exceeds 10% of the entire student body each year, makes extensive use of the Crum Woods as an outdoor classroom and laboratory.

Table 2. Courses taught in the Crum Woods (1998 through 2003) In each, at least some class meetings, laboratory exercises, or assignments took place in the Woods. List is not exhaustive.

division	course name	
Natural Sciences and Engineering	Animal Behavior	
	Animal Physiology	
	Behavioral Ecology	SEMINAR
	Biodiversity	SEMINAR
	Ecology	
	Embryology	
	Evolution	
	Field Ornithology	
	Field Studies in Animal Behavior and Natural History	
	Forest Ecology	SEMINAR
	Introduction to Environmental Protection	
	Introductory Astronomy	
	Invertebrate Zoology	
	Mechanics	
	Microbial Processes and Biotechnology	SEMINAR
	Microbiology	
	Organismal and Population Biology	
	Physiological Ecology	SEMINAR

(table continued on next page)

Table 2 (continued)

division	course name	
Natural Sciences and Engineering (continued)	Plant Competition: Native Versus Exotic Species	SEMINAR
	Plant Defense	SEMINAR
	Principles of the Earth Sciences	
	Spring Ornithology	
	Statistical Methods	
	Systematic Botany	
	Water Quality and Pollution Control	
Social Sciences	Environmental Education	
	Environmental History	
	Perception	
	Practice Teaching	
Humanities	Acting	
	Cultural Practices and Social Texts	
	Dance Composition	
	Dance Improvisation	
	Drawing	
	Elements of Musicianship	
	Foundation of Studio Arts	
	Intensive French	
	Intensive Spanish	
	Lyric Encounters	
	Oil Painting	
	Performance Dance: Modern	
	Religion, the Environment, and Contemplative Practice	
	Photography	
	Watercolor	
	Women and Religion	
	Writing Nature	
Interdivisional	Environmental Studies Capstone	SEMINAR
Physical Education and Athletics	Fitness Training	
	Track and Field	

1.4.1.2 Professional and student research

The earliest known use of the Crum Woods in a scientific study was by John W. Harshberger (1904), Professor of Botany at the University of Pennsylvania (see Section 1.1.5: Land-use history and other human influences on the landscape and its component ecosystems). Several Swarthmore professors have conducted part of their academic research in the Crum Woods. Most recently, a series of seminal papers in the field of plant ecology by Jacob Weiner, Sean Thomas and Glen Berntson reported the results of experiments on plant competition that they conducted in the Campus Woods while Dr. Weiner was professor in the Department of Biology and Drs. Thomas and Berntson were his students (Weiner and Thomas 1992; Thomas and Weiner 1989a, 1989b; Weiner et al. 1990; Berntson and Weiner 1991). José-Luis Machado, the current plant ecologist in the Department of Biology, is collaborating with students on several ongoing experiments in the Woods that are intended for eventual publication in the scientific literature, and other Crum Woods-oriented research projects are in the planning stages. Julie Hagelin, the animal behaviorist in the Department of Biology, also is conducting research in the Woods with involvement by students.

Students enrolled in Ecology (BIOL 036), ecology seminars, and several other biology courses with a field orientation over the past three decades have benefited from the proximity and quality of the Woods' resources as the site for hundreds of class laboratory exercises and independent research projects. The Woods' proximity has made this possible because student research normally entails independent work by small teams over an extended period of time, typically six to eight weeks, and students must have access to their field sites repeatedly, often at odd hours. The large area of undomesticated vegetation and soils has allowed for experimental replication, without which valid experimental design and statistical analysis are not possible.

Art McGarity, environmental engineering professor, has conducted field exercises with students in reaches of Crum Creek flowing through college property for 15 years. In Water Quality and Pollution Control (ENGN 063), students conduct flow-rate measurements, take streamwater samples, and analyze them in the laboratory. Dr. McGarity and his students have installed a water quality monitoring station in the creek with an electronic sonde, which records measurements every 15 minutes. The spring 2000 Environmental Studies Capstone Seminar (ENVS 091), "Water and Watershed Studies," focused entirely on the Crum Creek watershed as a case study. Seminar students helped to organize and run the Crum Creek 2000 Watershed Conference and Workshop, which attracted more than 100 participants to the campus in March, 2000 to discuss Crum Creek watershed problems and prospects for solutions. Numerous senior Engineering design projects and science Honors theses have involved student research in Crum Creek.

Researchers at institutions other than Swarthmore College also have used the Crum Woods in their work. Currently a Ph.D. student at Drexel University is conducting her

dissertation research in portions of the Campus Woods west of the creek. She is using a novel experimental method for testing hypotheses about how Norway maple — an important invasive species — commonly brings about a total collapse of native plant species diversity where it invades North American forests. The results may help land managers and conservation practitioners in developing more effective remedies for, and preventive measures against, the damage caused by the introduction of this species.

Some idea of the still-unrealized potential of the Crum Woods as a research facility can be obtained by comparison with Swarthmore's sister institutions. For example, the Hopkins Memorial Forest at Williams College, designated and staffed since 1971 as a major teaching resource and research facility of the college, to date has yielded 11 Williams College Center for Environmental Studies publications and more than two dozen theses and papers in the peer-reviewed scientific literature. The Connecticut College Arboretum, which does not include the built-up area of campus but consists mainly of natural areas and other land devoted since 1931 to ecological research, has been the focus of 40 small books in the Connecticut College Arboretum bulletin series and over 100 theses and published scientific papers. The potential is very strong for the Crum Woods to develop a national reputation, similar to that of Williams and Connecticut Colleges' forests, as a first-rate research facility.

1.4.1.3 Walking, quiet contemplation, and conversation

"Hiking or walking the trails" and "Sitting and enjoying the quiet" were the two most frequent uses reported by alumni when they were students (enjoyed by 96.9% and 94.2% of respondents, respectively; Appendix A) and by current faculty and their families (98.1% and 77.4%; Appendix B). "Talking with friends" was the fourth most frequent use reported by alumni (85.3%) but it was not included on the faculty questionnaire. These uses were the top three reported by current students (89.8%, 80.6% and 70.4%, in the same sequence as for alumni; Appendix C).

1.4.1.4 Birding and other forms of nature appreciation

"Viewing the plants and landscape" and "Watching birds or other wildlife" were the third and fifth most frequent uses reported by alumni when they were students (83.0%, 63.4), third and fourth for faculty and their families (67.9%, 60.4%), and fourth and seventh for current students (63.1%, 42.2%; Appendices A, B and C). The academic program fosters these activities among the roughly 200 students each year who enroll in the several field-oriented courses in biology.

1.4.1.5 Other passive recreation by members of the College community

"Passive recreation" may be defined as non-motorized outdoor recreational activities that:

- offer constructive, restorative and pleasurable human benefits that foster appreciation and understanding of natural lands, wildlife and ecosystem functions

- do not have significant adverse impacts to natural, cultural, scientific, or environmental quality values

- occur in a natural setting which is an integral part of the experience

- require only minimal visitor facilities and services directly related to safety and to minimizing passive recreation impacts

- are compatible with other passive recreation uses

Walking, quiet contemplation, conversation, and nature appreciation, whose usage patterns are described above, meet these criteria. Other such uses reported by a significant proportion of alumni, students, faculty and their families include picnicking, sketching, painting, photographing, sleeping outdoors, swimming, rock climbing, riding a trail bike, volunteer work, dog walking, bonfires, romantic pursuits, ice skating, sledding (and its popular variant, "traying"), meditation, the Crum Regatta, and playing games and exploring with friends (Table 3).

1.4.1.6 Horticultural activities

A small fraction of the horticultural work of Scott Arboretum takes place in the Campus Woods. The Frorer Holly Collection, donated to the Arboretum in 1973 by James R. Frorer (Swarthmore class of 1915), occupies about 2.5 acres (1.0 ha) of low slopes and floodplain along the northeastern perimeter of the Crum Meadow (see Figure 4). Wister's Garden, created by John Wister, Director of the Scott Foundation for its first 40 years, and his wife Gertrude, occupies the slope between Crum Creek and 735 Harvard Avenue, a house built for John Wister by the College. It is marked by a network of narrow footpaths, most of them paved (see Figure 4). About 1 acre (0.4 ha) of the garden area is still actively maintained. The Arboretum operates a small tree nursery, surrounded by a fence to keep out deer, of less than 1 acre (0.4 ha) on the Swarthmore Farm Plateau west of the creek (see Figure 2). Lawns are also maintained in the Woods, but this is not considered to be a primary use and thus is described under secondary uses, below (see Section 1.4.2.5).

Table 3. Passive recreational uses other than nature appreciation reported by survey respondents. Cells are left blank where less than 1.5% of respondents within the category reported the use. Uses preceded by an asterisk (*) were "write-ins"; others were provided as options on the questionnaires (see Appendices A, B and C).

	percentage of respondents:		
	alumni	students	faculty
Jogging or cross-country training on the trails	41.1	53.9	30.2
Picnicking	58.5	34.0	37.7
Sketching, painting, photographing, or creating other art	37.1	34.0	20.8
Sleeping outdoors	23.7	19.4	
Swimming	20.1	20.4	3.8
Rock climbing	14.3	18.9	17.0
*Dog walking			18.9*
Riding a trail bike	5.4	9.2	13.2
Volunteer work			9.4
*Bonfires	1.8*	5.2*	
*Dating, romance, sex	4.9*		
*Ice skating	3.6*		
*Meditation	3.1*	1.9*	
*Crum Regatta	2.7*		
*Playing games or exploring with friends	2.7*		
*Sledding, "traying"	2.2*		
*Escaping pressures, "preserving sanity"	1.8*		

1.4.1.7 Volunteer stewardship activities

Involvement by volunteers in stewardship of the Crum Woods dates back at least to the early 1970s, and perhaps much earlier, but until around 1990 it was sporadic. Woods volunteer organizing has been partly a grass-roots phenomenon, originating separately among Swarthmore College students and among local residents, including College staff members and their families. Initially, students enlisted help from the Department of Biology in organizing a student volunteer trail-maintenance corps, which at one point included the cross-country team (S. Major, personal communication). Their work consisted of installing water bars on eroded sections of trail and placing structures alongside trails to hold runoff-slowing organic matter in place. Student volunteer activity in the Woods peaked in the mid-1970s and again in the early 1990s but there has been a hiatus in student involvement since then. Several local residents and College staff members have organized volunteer clean-ups of logjams and floating debris from Crum Creek (D. Hasbrouke, personal communication). These were family events on

Saturdays, typically involving on the order of 50 to 100 people. On a few occasions, small numbers of volunteers who are staff members of the Office of Alumni Relations have also worked to clear logjams and floating debris from the creek to improve the campus's appearance for Alumni Weekend.

The main activities performed by volunteers in the Crum Woods are trail maintenance, removing invasive plants, cleaning up litter and other debris from the Woods and Crum Creek, placing cut brush on slopes to control erosion, leading nature walks, and helping with restoration plantings. Currently, a volunteer woods crew of local residents and College staff members works one day a week during the winter months in the Campus Woods (see Appendix D). They are self-organized but they carry out their work under the direction and supervision of Scott Arboretum personnel. Of 10,379 hours logged in 1999 by Arboretum volunteers, 8,078 in 2000, 9,506 in 2001, and 7,421 in 2002, the woods crew accounted for 549, 303, 299, and 309 hours' labor, respectively (C. Sawyers, personal communication), from just over 3% to more than 5% of the total. Friends of Smedley Park is a community volunteer group with no ties to the College that performs trail maintenance and cleanup work in the Martin Forest (J. Auten, personal communication).

1.4.2 Secondary uses

Secondary uses, with some minor exceptions, are those that do not contribute directly to the education and quality of life of Swarthmore College students. Most such uses impose some constraints on the value of the Woods for education and the quality and capacity of the Woods to provide ecosystem services. However, in many cases secondary uses are associated with collateral or indirect benefits to the College and its mission. Thus, secondary uses often represent a trade-off between an indirect benefit to the College and reduced opportunity or resource quality for teaching, research, and other primary uses. In some cases, secondary uses may interfere with the effective stewardship of significant elements of the region's natural heritage or environmental quality, e.g., a Natural Area, a threatened species, or the integrity of the Crum Creek ecosystem. The severity of a secondary use's impact on primary uses, natural heritage, and environmental quality varies among uses and sites. In locations where secondary uses have detrimental conflicts with the primary uses or threaten to degrade the value of the Crum Woods for those uses, one of the purposes of this plan is to define remedies.

1.4.2.1 Composting facility

The Borough of Swarthmore has operated a leaf-composting facility since the 1960s in an open part of the Campus Woods surrounded by forest, near the center of the Swarthmore Farm Plateau on the west side of Crum Creek. In 1992, Nether Providence Township joined the enterprise and the facility was greatly expanded. The current lease specifies a "limit of disturbance" encompassing approximately three acres (1.2 ha) but

the operation has spilled over into a somewhat larger area of perhaps 4 acres (1.6 ha). About one-third of the area used by the operation is paved; the remainder, including two runoff detention basins of about 3,000 and 12,000 sq. ft. (280 and 1,100 m^2) is mowed or scarified and compacted by vehicular use.

The two municipalities lease the land for $1 per year. The lease is for two years, renewed automatically on 1 September in odd-numbered years unless terminated, with two years' notice, by either party. In the early 1990s, the lessees installed a 58,000-sq. ft. (5,400-m^2) platform and a 360 by 12-ft. (110 by 3.7-m) access road, built of 4,100 tons (3,700 Mg) of foundation stone and bituminous pavement (J. Billings, personal communication). Two pieces of large machinery are kept on the property year-round: a SCAT compost windrow turner (SCAT Engineering, Inc., Hopkinton, IA) and a wheel loader (large tractor and front-end loader) for repositioning material and loading trucks. Earth-moving and dumping activity has encompassed approximately 70,000-sq. ft. (6,500-m^2) of additional land adjacent to the composting platform within and slightly beyond the "limit of disturbance" boundary specified in the lease.

The yearly activity cycle has three major parts (J. Breitmayer, personal communication; C. Rowles, personal communication). Leaves are harvested from residents' street frontages and trucked in from late October through early December. Leaves are distributed in windrows about 280 ft. (85 m) long and 15 ft. (5 m) wide, which are turned to facilitate the fermentation process approximately weekly from mid-December through early April. The finished compost is distributed by truck to property owners and to each of the two municipalities' recycling centers from mid-April through June.

Input and production were each approximately 2,100 tons (1,900 Mg) in the 2001–2002 season (J. Breitmayer, personal communication; C. Rowles, personal communication). Seven trucks with capacities of 6 and 10 cubic yds. (4.6 and 7.6 m^3) bring in and take out, on average, roughly 2,000 truckloads per season. Approximately one-quarter of the total comes from the Borough of Swarthmore and the remainder from Nether Providence. A small fraction of each year's production is sent to the Delaware County leaf composting site solely for the purpose of obtaining average truckload weights, which are extrapolated to compile statistics in compliance with state regulations requiring yearly production reports.

1.4.2.2 Material storage and disposal

Swarthmore College Facilities and Grounds and the Scott Arboretum currently use more than 30,000 sq. ft. (9,000 m^2) of land in the Campus Woods, mainly on the Swarthmore Farm Plateau near the composting facility, to store used building stone, scrap metal, and broken concrete and to dispose of cut logs, tree branches, uprooted shrubs, and other organic refuse (Figure 18).

In past years, large quantities of debris and landfill material were dumped in the floodplain at the inside bend of the curve in Crum Creek southwest of the Lamb-Miller Field House, an area now known as Skunk-cabbage Hollow. The dumping no doubt occurred during a time when the extraordinary value of floodplains and wetlands for floodwater retention, groundwater recharge, water purification, nutrient assimilation, wildlife habitat, and other ecosystem services was not yet widely recognized. This now-inactive dump is heavily infested with introduced invasive plant species, in contrast with the surrounding, intact sections of the wetland, which have some of the highest diversity of native animal and plant species of any similar-sized area in the Crum Woods.

Several scattered areas still have significant accumulations of trash from past illicit dumping. Some are along the Leiper Trail — the interface between the Campus Woods and the Blue Route (I-476) — and another adjoins the parking lot at the campus water tower. They include construction debris and the remains of large appliances. Several others are in the Woods adjacent to neighboring residential properties. These contain mostly small construction debris (bricks, lumber scraps, etc.) and organic material from pruning, mowing and weeding. Dumping may still be occurring at one or more of the residential sites.

1.4.2.3 Passive and active recreation by the public

The main recreational uses of the Crum Woods by the public are trail walking, jogging, dog walking, and trail (and off-trail) biking. These are the principal uses in the Martin Forest tract, leased by the College to Delaware County and included in Smedley Park. Other recreational uses by the public include swimming, picnicking and fishing, mainly in the lawn area between Crum Creek and Strath Haven Condominiums and next to the dam just off Yale Avenue.

No estimates of public visitation rates are available for either Smedley Park (Menke and Menke 1990) or for the Campus Woods, but it is likely that each receives tens of thousands of visits per year by at least several hundred local residents. Both areas are widely viewed in the surrounding communities as important public amenities.

1.4.2.4 Illicit activities

Although large in area, the Crum Woods have far fewer reported incidents requiring action by public safety officers than the built-up area of campus and surrounding communities. It is possible that illegal activities are underreported there because perpetrators find it easier to hide in the Woods, but most of the disparity probably arises simply because far fewer people are in the Woods, whatever their intentions may be.

For many years, the most common illicit use of the Woods was underage alcohol consumption, mainly in the Crum Meadow. Late-evening gatherings of 50 to 100 teenagers from surrounding communities were not uncommon. In the last 15 to 20 years, the College's Office of Public Safety and the Borough of Swarthmore Police Department have instituted new procedures that have greatly reduced the size and frequency of adolescent beer parties in the Woods, although they still occur on occasion (O. Redgrave, personal communication). Bicycle patrols of the Leiper Trail, instituted relatively recently by the Township of Nether Providence Police Department, may help to curb the incidence of underage drinking on the west side of the Campus Woods.

The most common illicit use by Swarthmore College students is making bonfires in the Crum Meadow and failing to douse them thoroughly before leaving. At this writing, the Office of Public Safety is on the verge of instituting a permitting procedure for students wishing to have a bonfire in the Meadow (O. Redgrave, personal communication). Applications will be subject to approval by the Dean's office, the Director of Grounds, and a Borough official. A $50 deposit will be refunded when students return two fire extinguishers that must be kept on hand as part of the required bonfire protocol. Only recognized student organizations and dormitory groups under the supervision of a resident assistant will be eligible.

There is some confusion about the rules and ordinances concerning dogs. Many town residents walk their dogs in the Campus Woods, mainly on the trails on the Swarthmore side of Crum Creek and in the Crum Meadow. According to a Swarthmore ordinance, dog walkers must keep their pets on a leash or in close proximity or under voice control at all times, anywhere in the borough. However, the terms "close" and "control" are not defined and there is considerable divergence in opinion between some dog walkers and some other visitors who come to jog, walk, watch birds and other wildlife or sit quietly. Dog complaints are a significant fraction of public safety incidents in the Campus Woods. The current policy of the Office of Public Safety is to follow up attentively all such complaints, but there is almost never a verifiable violation except in exceedingly rare instances when someone is bitten (O. Redgrave, personal communication).

Illicit uses that are obvious to anyone familiar with the Campus Woods include painting graffiti on the railroad trestle and littering, however, such casual or hidden violations have rarely if ever been the targets of enforcement. Staffing levels are such that virtually all enforcement and other duties by campus public safety officers and the local police are incident-driven. If there is any time left over for preventive patrols, very little is spent in the Woods, in part because the rates of safety violations and illicit activity there are justifiably perceived to be lower than in other parts of the officers' jurisdictions.

Times when on-duty public safety officers entered the Campus Woods in the three years prior to this writing numbered only 43 (O. Redgrave, personal communication). Nearly one-third involved providing information, medical or other assistance. A few

were routine patrols or maintenance visits. Nearly one-third were investigations of complaints or causes for suspicion in which either nothing was found or a violation could not be confirmed. Another one-quarter involved safety violations or illegal activity: four fires, four other safety-related calls, and one incident each of parking violation, indecent exposure, and vandalism.

1.4.2.5 Mowed turf

Approximately 25 acres (10 ha) of the Crum Woods are classified as mowed turf (Figure 4). These are areas dominated by introduced grass species and maintained by periodic mowing during the growing season. An additional 10 acres (4 ha) are classified as landscaped areas, which are partly in mowed turf (Figure 4). The portion of the Woods that is mowed is equivalent in area to between 25 and 30 football fields[5]. (This does not include the main campus and College-owned residential properties that are not in the Woods, totaling approximately 177 acres [71.6 ha], well over half of which is in mowed turf.) The largest mowed areas in the Woods are the Crum Meadow (also known as Palmer Meadow), 6.0 acres (2.4 ha), and the lawn at Crumwald Farm (Clarke House and vicinity), also 6.0 acres (2.4 ha). Most of the rest surrounds the composting facility (4.0 acres/1.6 ha), the Castanea House and Scott Arboretum nursery (3.2 acres/1.3 ha), and the Old Mill House (0.9 acres/0.4 ha).

1.4.2.6 Utility easements

Three pipeline systems cross the Crum Woods, accounting for a total of approximately 20,200 ft. (6,160 m) or 3.8 mi. (6.2 km) of pipeline rights-of-way on College land in both the Campus Woods and Martin Forest.

Buckeye Pipeline Company has an 8-inch (20-cm) diameter petroleum pipeline crossing College property parallel with Crum Creek for the entire length of the Campus Woods, 1.5 mi. (2.4 km) from Plush Mill Road at the north end to Avondale Road at the south end. The company performs right-of-way maintenance twice a year, cutting tree branches, whole trees, and shrubs to keep an access path open (D. Kane, personal communication). The width of the path varies depending on the availability of vehicular access. In areas that connect to a road, the cleared right-of-way is up to 50 ft. (15 m) wide. Three such segments exist: 400 ft. (120 m) at the north end of the Campus Woods adjoining Plush Mill Road; about 1,400 ft. (430 m) through Crum Meadow; and about 600 ft. (180 m) on the Swarthmore Farm Plateau just north of the composting facility. On most of the remainder, the cleared path is as little as one-tenth as wide.

A Philadelphia Suburban Water Company underground aqueduct crosses the upper end of Martin Forest for a distance of 480 ft. (145 m). A lane cleared of all trees, which varies in width between about 30 and 50 ft. (10–15 m), marks the right-of-way through

[5] By National Football League regulations, 360 by 160 ft. (110 x 49 m).

the old-growth forest. The Water Company hires a private contractor for periodic maintenance.

About 2.2 mi. (3.5 km) of municipal sanitary sewers crisscross College land in the Crum Woods. A 36-inch (91 cm) diameter trunk line parallels Crum Creek with a total length of 8,200 ft. (2,500 m) along the length of the Campus Woods and 1,640 ft. (500 m) in two segments that cross Martin Forest. Joining the trunk line between Plush Mill Road/Wallingford Road and Yale Avenue/Avondale Road are four feeder lines. They and their branches run a total distance of approximately 1,940 ft. (590 m) in the Campus Woods. The feeders tie in from Ogden Avenue/Elm Avenue (the lower 860 ft. [260 m] of pipe lie within the Campus Woods), Rogers Lane/Crumwald Lane (50 ft. [15 m]), Fieldhouse Lane/Crum Ledge Lane (500 ft. [150 m]), and Harvard Avenue/Strath Haven Condominiums (530 ft. [160 m]). None of the sewer rights-of-way in the Woods shows any visible signs of periodic clearing of woody vegetation. The lines are generally invisible except for the maintenance access holes, which protrude one or two ft. (0.3–0.6 m) above ground level and are spaced, on average, roughly 260 ft. (80 m) apart.

1.4.2.7 Individual residences

There are 17 College-owned residences in the Campus Woods (Table 4). They and their landscaped areas and lawns total 14.3 acres (5.8 ha), nearly half of which is the very large lawn that extends the full 550 ft. (170 m) between the Clarke House and Rogers Lane, covering an area equal to 4½ football fields.

Table 4. College-owned residences in the Crum Woods.

residence(s) at each location	associated landscaped and mowed turf area
Eight townhouses (two quadraplexes) on Crum Ledge Lane*	0.8 acre (0.3 ha)
735 Harvard Avenue, "The Lodge" (737 Harvard Avenue),* 739 Harvard Avenue, Cratsley House (741 Harvard Avenue)	2.7 acres (1.1 ha)
Old Mill House (405 East Rose Valley Road)†	1.3 acre (0.5 ha)
Castanea (or Garrett) House (302 Avondale Road)†	0.5 acre (0.2 ha)
Crumwald Farm†: Clarke House (401 Rogers Lane), 405 Rogers Lane	8.5 acres (3.4 ha)
445 Rogers Lane	0.5 acre (0.2 ha)

* Listed as Swarthmore Borough historic resource (Delaware County Planning Department 2001)
†Listed as potential site of historic significance in Delaware County (Berge et al. 1991)

Five of these residences or residential clusters have been listed as historically significant or potentially significant:

- The Crum Ledge faculty houses consist of two quadraplexes built in 1946 by the College in the Woods 300 feet (90 m) southwest of the Field House.

- One of the four houses belonging to the College just inside the edge of the Woods along Harvard Avenue, number 737, was built in 1900 by Frederick M. Simons, who originally intended it as a men's social and civic club and dubbed it "The Lodge." Mr. Simons, a wealthy Philadelphia jeweler, eight years earlier had built the nearby Strath Haven Inn, a 100-room luxury summer hotel overlooking Strath Haven Lake. He and his family used 737 Harvard Avenue as a summer residence and later as their year-round home (Delaware County Planning Department 2001).

- The Old Mill House is the only remaining structure, other than ruins of foundations and the millrace, of the Strath Haven Mills complex (see Section 1.1.5: Land-use history), located on the Nether Providence side of Crum Creek next to the dam. The first buildings were constructed in 1776 but several generations of buildings fell into ruin or were torn down and replaced over nearly 150 years. The age of the present house is unknown but it is likely to date from at least as long ago as the late nineteenth century.

- The Garrett House or "Castanea," at 302 Avondale Road in Nether Providence Township was an elite suburban residence in the late nineteenth century, perhaps remodeled from an earlier farmhouse of unknown age (Berge et al. 1991). It appears on an 1889 map in a tract of 19 acres (7.7 ha) belonging to Powell Stackhouse (Smith 1889) but the property was part of a 133-acre (53.8 ha) farm on older maps (Smith 1880).

- The Clarke House and surrounding buildings, including two faculty residences, are parts of the historic Crumwald Farm. An 1889 map shows two buildings, which appear to be at the locations of the present Clarke House and main barn, on a tract of 63 acres belonging to a C. H. Godfrey (Smith 1889). A 1909 map depicts at least nine additional structures surrounding the two original buildings; the parcel had decreased to 54 acres and was owned by an R. W. Downing (Mueller 1909). These maps may document the property's conversion from a small dairy farm (Berge et al. 1991) to an elite suburban residence. Architect R. Brognard Okie built the Clarke House in 1927 in Colonial Revival style for William A. and Eleanor Stabler Clarke (Berge et al. 1991). Swarthmore College purchased the property in 1975.

1.4.2.8 Local primary and secondary school education

Although no systematic inventory has yet been conducted, a substantial number of the alumni, students, faculty and members of the larger community surveyed and interviewed for this plan (Appendices A, B, C and D) described local school teachers taking their students into the Crum Woods during classes. A study funded by a Swarthmore Foundation grant and supervised by environmental engineering professor Art McGarity brings volunteer Swarthmore students together with students and teachers from Chester High School in a community-based learning project to assess streamwater quality in the Crum Woods. Students from the College's Department of Education assigned to local elementary school teachers for their practice teaching have used the Woods to present lessons in biology and the environment.

1.4.2.9 Classes from other institutions of higher education

Faculty members from several institutions other than Swarthmore College teach in the Crum Woods. The Woods have been the principal teaching site for the Field Ecology course offered by the Department of Biology, Bryn Mawr College (A. Herzig, personal communication), and serve also as a field site for the Ecology course and student research at the Biodiversity Laboratory, Department of Biology, St. Joseph's University (S. McRobert, personal communication). The Swarthmore English Department's Writing Nature class during a recent session in the Woods happened upon the Oil Painting class from the Pennsylvania Academy of the Fine Arts. Although a complete survey may not be feasible, it is reasonable to assume that the instances known to the authors of this document are just a fraction of the pedagogical use of the Woods by other institutions.

2.0 Conservation and Stewardship Priorities

The conservation priorities of any property should be the fundamental basis for every stewardship program and activity. Conservation priorities can be ecological, recreational, historical, or programmatic depending on the local landscape context of the site, legal restrictions, the historical use of the property, and the goals of the landowner. The conservation priorities of the Crum Woods are logically dictated by how this extraordinarily valuable asset can be best used in fulfilling the mission of the College. However, the point must be made that the Woods cannot be expected to fulfill all parts of the College's mission. The key question is, which parts of the mission are the Woods *uniquely* suited to fulfill? Secondarily, what other functions and benefits can the Woods also provide without compromising these unique capabilities? Some uses, even those that would fulfill important parts of the College's mission or that are highly popular and in demand, must be limited or rejected because they are incompatible with particular unique and irreplaceable values of the Woods. Responsible stewardship entails diverting such uses to more appropriate terrain.

The conservation and stewardship priorities for the Crum Woods have been classified into two categories. Programmatic priorities are those that relate directly or indirectly to the fulfillment of the College's mission. These overlap with ecosystem function priorities, which concern the Crum Woods' ability to continue delivering high-quality pedagogical benefits and "ecosystem services" sustainably over the long term. Ecosystem services may be defined as the "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997). In the Crum Woods, they include aquifer recharge, flood control, sediment retention, erosion control, soil development, nutrient assimilation, local climate regulation, wildlife habitat, and opportunities for education, research, nature appreciation, and quiet contemplation.

2.1 PROGRAMMATIC PRIORITIES

A succinct statement of the College's mission is given under "objectives and purposes" in the *Swarthmore College Bulletin*.

> *Swarthmore students are expected to prepare themselves for full, balanced lives as individuals and as responsible citizens through exacting intellectual study supplemented by a varied program*

of sports and other extracurricular activities. The purpose of Swarthmore College is to make its students more valuable human beings and more useful members of society. Although it shares this purpose with other educational institutions, each school, college, and university seeks to realize that purpose in its own way. Swarthmore seeks to help its students realize their fullest intellectual and personal potential combined with a deep sense of ethical and social concern.

The Crum Woods are a unique educational facility whose presence at the edge of campus and nearby helps the College to fulfill its mission in several ways.

2.1.1 Educational assets

The Crum Woods foster "*exacting intellectual study*" by serving as:

- a laboratory for coursework and research in biology, engineering, environmental science, earth science, statistics and psychology;
- a studio for art, dance and drama; and
- an inspirational setting for classes in writing, religion and history.

College faculty have used the Woods in their own research, which confers many direct and indirect benefits to students including opportunities to work with their professors as research technicians or to carry out their own, related studies as Honors or independent research projects for credit and, in some cases, publication. The Crum Woods also serve an educational function in the larger community, which can feed back to provide special educational opportunities for Swarthmore College students. Local elementary school teachers, including student teachers from the College's Department of Education, use the Woods in classes on biology and the environment. Researchers from other colleges and universities conducting biological research in the Woods have involved Swarthmore students in their work. A major purpose of this plan is to insure that a unique and important part of the College's educational capital is utilized to the fullest.

2.1.2 Good stewardship as an act of social responsibility

The size of the Campus Woods has dwindled repeatedly since portions were first cleared for farming in the late 1600s. The forested area is now too small to sustain local populations of several native forest-interior species of birds and other wildlife. Any further attrition is highly likely to result in the local extinction of more native forest species from the Crum Woods and central Delaware County. Recent and ongoing declines in species diversity are partly due to the reduction in the size of the contiguous forest block resulting from the construction of I-476 and to smaller incursions into the Campus Woods' edge by campus construction projects. The world is in the midst of the greatest biodiversity crisis since the catastrophic mass extinction that destroyed the

dinosaurs and impoverished the world's ecosystems for millions of years. More and more institutions are recognizing a responsibility to "think globally, act locally" and to undertake a true accounting of long-term costs in assessing net short-term benefits.

Because it rests within a regionally significant natural area, the College is uniquely positioned to use the land-use conflicts both within and outside the campus as a real-world learning experience for students. Utilizing on-site natural areas to discuss land-use priorities and how to properly steward remaining natural areas is an opportunity few colleges can offer. This further confirms the need to recognize the Crum Woods as an invaluable educational facility.

The undeveloped portion of the College's land[6] is a significant property not only for its size — 204 acres (82.6 ha), of which 85% is forested — but also for the diversity and health of the natural habitats that occur there. Over time, these lands will become more and more important as development pressures increase and open space and natural areas are lost. Proper stewardship of the Crum Woods is crucial to nurturing "*a deep sense of ethical and social concern*." Those who engineered the College's piecemeal acquisition of the Woods could not have foreseen that they would one day comprise perhaps the best of only a handful of forested tracts that resemble Delaware County's original forest. Stewardship of such a unique resource, whose value for education and environmental quality is ever increasing, is the right thing to do from a societal perspective. An educational institution, in particular, owes its students, alumni, and the greater community the duty to hold itself accountable for setting an example of responsible stewardship.

2.1.3 Opportunities for passive recreation[7] and contemplation for the College community

In many other ways besides those related to the curriculum, the Crum Woods support students in their pursuit of "*full, balanced lives as individuals*" and provides unparalleled opportunities for a variety of "*other extracurricular activities*." The founders recognized the value of integrating nature into the educational experience and of providing opportunities for retreat to a place of peace and beauty. An 1863 assessment of the suitability of several alternative sites ringing Philadelphia as a location for the proposed college uniquely praised the land near Crum Creek, Delaware County: "… no place offered to the Committee affords such romantic and secluded rambles as the rocky and sloping hill-sides which bound this stream" (Hull, undated). In 1865, Edward Parrish, reporting on the present site's final selection, wrote "the wood-land is ample for shaded walks, and the banks of the stream afford a feature of romantic beauty rarely

[6] The College's undeveloped land is the Crum Woods minus areas that are either paved (e.g., the composting platform on the Swarthmore Farm Plateau), landscaped (mainly around faculty/staff houses in the Woods), or mowed (e.g., Crum Meadow and the lawns near Strath Haven Condominiums and the Clarke House).

[7] Passive recreation is defined in Section 1.4.1.5.

surpassed" (Hull, undated). Surveys conducted as part of this plan (Appendix C) indicate that the majority of present students use the Crum Woods to hike and jog the trails, sit and enjoy the quiet, talk with friends, and take pleasure from the plants and landscape. Smaller proportions of respondents engage in many other non-curricular uses as well, including watching birds and other wildlife, picnicking, sketching or painting, photography, swimming, sleeping outdoors, and rock climbing.

2.1.4 Opportunities for active recreation

In general, there is little opportunity for active recreation within the Crum Woods. The relatively steep topography, existing plant and water resources, and the potential for adverse impacts to pedagogical and passive recreational activities argue that this component of the College's mission is best fulfilled in more appropriate areas of the campus. Indeed, current uncontrolled active recreation in the form of mountain biking is damaging plant and soil resources and creating conflicts with trail walkers.

It appears that opportunity is very limited for allowing bike use that does not impact the safety and enjoyment of pedestrians and does not degrade natural resources. Biking on some sections of the flat trails along Crum Creek might minimize the latter concern; however, most of the established trails (including sections of the creek trails) are too narrow and steep to make bike use compatible with higher priority uses. The only possibility for a recreational bike trail that addresses these concerns and provides a continuous trail for bikers (uninterrupted by narrow or steep sections) is a loop trail in the area from Crum Ledge to the railroad trestle. Even on these trails, however, bike use will not be compatible with other uses (walking, nature study) if it becomes too frequent. Use of all Crum Woods trails should be off-limits to organized biking, for example, by a club or for a training exercise.

The only area of Crum Woods that may be appropriate for organized forms of active recreation is on the west side of Crum Creek on the plateau that runs from the composting facility to the Castanea House. Section 4.10.3 identifies potential active recreation sites in this area that could meet the physical requirements for ball fields. The plans show the associated impacts on natural resource values, particularly on critical interior forest habitat, for several athletic field scenarios.

2.1.5 Promotion and recruitment

A sizable fraction of the students canvassed as part of the planning process (Appendix C) reported that they had originally been hesitant to choose Swarthmore because of its urban-suburban location, but their concern was allayed when they learned of the Crum Woods. Significant forested landholdings, especially adjacent to campus, are an exceedingly rare commodity at institutions of higher learning. Among the 72 liberal arts colleges in the Northeast (U.S. News 2002), there are substantial college-owned forestlands within walking distance of campus at only seven (Table 5). The Crum

Woods are among the smallest of these, but some of the site's qualities nonetheless allow it to rank with the best. The others, along with other Northeastern colleges with forest landholdings some distance from their campuses, were surveyed as part of this planning effort. Administrators and faculty members at virtually all of these institutions stressed the benefits of protecting and investing in their forestlands to their competitive position in attracting the best prospective students. For example, Williams College's 2,400-acre (9.7 km^2) Hopkins Memorial Forest, a 15-minute walk from campus, is comparable to the research stations of several large universities in terms of the number of student-faculty collaborative publications reporting the results of research conducted there (www.williams.edu/CES/hmf/).

Table 5. Northeastern colleges with forest landholdings large enough to include functioning forest interior. Information gathered by Roger Latham by field investigation and by consultation with administrators and faculty at each institution, from other colleges' web pages, and from the Organization of Biological Field Stations (www.obfs.org).

college	woods & other undeveloped land on-campus, in acres (ha)	woods & other undeveloped land off-campus, in acres (ha)	forest health & integrity	on-site research facilities
Bates		640 (260) (leased)	good to excellent	research station
Bowdoin		440 (180)	fair to excellent	two research stations
Colby	160 (65)	34 (14)	fair to excellent	no
Connecticut	750 (300)		poor to very good	no
Dickinson		3,400 (1,400) (leased)	poor to fair	research station
Mount Holyoke	550 (220)		poor to very good	no
Skidmore	350 (140)		fair to very good	no
Swarthmore	204* (83*)		fair to very good	no
Vassar	280 (110)		poor to fair	research station
Williams	2,400† (970†)		good to excellent	research station

*30 acres (12 ha) of the total are in a separate tract 1 mi. (1.6 km) from campus.
†Located 1 mi. (1.6 km) from campus.

2.1.6 Conflicts among priorities

There are other priorities that relate directly or indirectly to the fulfillment of the College's mission. Whether a facility should be used to advance a specific priority must be evaluated based on the facility's particular capacities and suitabilities. For example, the new Science Center is not required to help fulfill the "*varied program of sports*" part of the College's mission, nor would Parrish Lawn be chosen as the site for a new parking facility. Similarly, the Crum Woods can absorb only a limited range and intensity of other uses before their ability to be a top-notch outdoor classroom, research facility, attraction to prospective students, and place for work-saturated students to "get away from it all" is placed at risk.

Even though passive recreation and contemplation are the most popular uses of the Crum Woods among members of the College community as well as the broader public, there are instances in which such uses are not fully consistent or compatible with scientific and educational values. In such cases, it is our contention that the scientific and educational values must be placed above other values in terms of management priority. This is for two main reasons. First, the resources that make the Woods an outstanding outdoor laboratory and classroom in many cases are fragile and cannot be sustained if exposed to certain types or levels of recreational use. Secondly, the unique opportunities afforded by the Woods for research and teaching are far rarer in the community and region than are opportunities for outdoor recreation.

2.1.7 Benefits to the larger community

The College's ability to carry out its mission effectively depends partly on good neighbor relations. As proprietor and steward of the Crum Woods, the College merits the larger community's respect and gratitude by preserving open space where it has all but disappeared, and by providing opportunities for passive recreation to local residents.

2.2 ECOSYSTEM FUNCTION PRIORITIES

All of the benefits that the College and the wider community derive from the Crum Woods and Crum Creek are rendered by the organisms that live there in the course of their everyday interactions with each other and with rock, soil, air and water. A half-billion years of evolution have fine-tuned these interactions; the result is a functioning ecosystem of surpassing complexity whose byproducts include natural beauty, wildlife habitat, aquifer recharge, flood control, sediment retention, erosion control, nutrient assimilation, local climate regulation, and a host of other ecosystem services that comprise the human life-support system. For most of its existence this machinery was self-sustaining but the growth of human technology and population density has resulted in the extermination of many native species and drastically altered the

interactions of those remaining. These changes, some irreversible, mean that the days are long gone when we can take ecosystem function for granted, especially in an urbanized landscape such as southeastern Pennsylvania's, where natural communities persist only in scattered fragments. Scientific understanding and resolute effort must continually be applied to counteract the unintentional impacts of human activity. Otherwise these fragmented and beleaguered ecosystems, and the benefits they provide, face continued deterioration and loss.

2.2.1 Crum Creek and tributary streams

Swarthmore College has direct control over just a small fraction of the influences on water quality and aquatic ecosystem integrity in Crum Creek. Of the creek's watershed, or total area of land from which runoff and groundwater eventually go into the stream, College lands comprise only 1.5% (Figure 3). The watershed above the south end of campus, 4.0 mi. (6.4 km) upstream from the creek's mouth at the Delaware River, spreads across 32.3 sq. mi. (82.7 km^2) of Delaware and Chester Counties (84% of the creek's entire watershed), including parts of 12 townships and boroughs. Nonetheless, what happens on the College's property has a disproportionate influence on the creek because its land includes the streambank, floodplain and adjacent slopes along nearly a tenth of Crum Creek's total length of roughly 23 mi. (37 km). The Crum Woods also encompass the lower reaches of four perennial streams that flow into Crum Creek, as well as six or more streamlets whose flow is intermittent. Although almost no data have been gathered, past incidents such as chemical contamination (e.g., fuel oil, pesticides) and changes in runoff patterns originating in campus construction projects have had visibly harmful impacts on stream water quality and aquatic ecosystem integrity. Conversely, adverse effects have been minimized in some cases by more conscientious approaches in the design of buildings and paved surfaces, choice of construction practices, and storage and deployment of chemicals.

2.2.1.1 Water quality

The water quality in the section of Crum Creek adjacent to campus is rated by the Pennsylvania Department of Environmental Protection as "impaired" due to agricultural impacts, habitat modifications, urban runoff and upstream dams. By contrast, the headwaters above West Chester Pike (Pa. Route 3) have been designated as a "high quality stream," owing to the low percentage of pavement and buildings in that part of the watershed and relatively intact riparian forests along the stream itself. The upper reaches of Crum Creek provide a model for how the mid- and lower reaches might be improved. Progress toward this goal will involve much work on a very large scale, to advance broad land-use and land-management changes across much of the creek's entire 38.4-sq.-mi. (98.3-km^2) watershed. Nonetheless, the College can make significant contributions to the improvement of water quality in the Creek and its tributaries on the campus and surrounding neighborhood.

Siltation is probably the most significant source of impairment to the health of the stream ecosystem and constraint on animal and plant diversity in the creek. It can be reduced by restoring riparian forest buffers — needed along about a quarter of the College's total Crum Creek frontage — and by improving stormwater management to settle out and filter silt-laden runoff from the built-up areas of campus and prevent gullying and other erosion on Crum Woods slopes. Masses of floating debris trapped against logjams in the Campus Woods section of the creek are a severe aesthetic nuisance, worth an investment in practical remedies. Perhaps the greatest impact can be made by sustaining the College's pivotal role in the important work begun by Professor Art McGarity to bring together stakeholders from throughout the watershed, fostering action to solve water quality problems using good science and the best available management practices.

2.2.1.2 Stormwater management

The College campus includes stormwater runoff conditions that reflect both the problems and solutions associated with urban runoff. The amount of rooftop, paved surface, and lawn area surrounding and draining into Crum Woods is substantial enough to alter the natural hydrology of groundwater and surface water, even given the relatively natural conditions in the Woods themselves. Evidence of this alteration includes gully erosion areas on slopes, extensive sedimentation at the base of slopes and in streams, former wetlands and small streams that are now dry part or all of the year, and degraded or altered plant communities. The issue of stormwater management was underscored previously by consultants to the College (Andropogon Associates 1988) as one of the most critical for halting degradation and undertaking restoration in the Campus Woods.

Since then, the College has undertaken a number of positive measures on campus to address stormwater management and its potentially negative effects. Several examples include (R. Merz, S. Hain, C. D. Burkett, personal communication):

- A cistern was installed under the parking lot behind Martin to collect runoff and then allow it to be drained slowly into the regular stormwater system.

- In compliance with a new Swarthmore Borough stormwater ordinance, an existing crowned turf football field was replaced with a new synthetic all-weather surface that allows water to pass through it into a 10-inch (25-cm) clean stone bed designed to recharge a two-year storm. Runoff from this bed is discharged into the stormwater collection system. The peak rate of discharge from the site for all design storms above the 2-year up to and including the 100-year storm does not exceed the peak discharge from those storms before disturbance, even assuming the original football field was a meadow. The new field also does not require chemicals to manage the turf and even minimizes the use of line paint, as the lines are a permanent pigment in the turf fiber.

- A "bio-swale" was created between McCabe Library and the Benjamin West House to convey stormwater from the upper campus to the Chester Road collection system in an open channel instead of a closed conduit. This improves the quality of the stormwater and mitigates flood potential downstream in several ways. The swale is an open, stone-lined channel planted with vegetation adapted to wet conditions. The stone lining increases the area of flow and the friction coefficient above those of a typical pipe section, resulting in decreased velocity and increased time of concentration. This results in a reduction of the flood impact of the stormwater discharged from the swale to the downgrade collection system and ultimately, Crum Creek. The stone lining also causes the stormwater to be aerated and filtered as it flows down the slope, improving the water quality. In addition, the plants installed in the swale and along its banks take up part of the stormwater nutrient load as part of the metabolic process, which further improves water quality.

- A "green roof" was constructed on the Papazian storage shed, planted with low-growing, drought-tolerant plants in a specialized growing medium. Such installations can detain 40% to 90% of stormwater runoff.

- Experiments have been conducted with the use of porous paving.

The new Science Center currently under construction also has innovative, and purposely visible and dramatic, stormwater measures designed into it. Precipitation that falls on the roof of the Commons, the lecture hall, and the connector to the chemistry wing will be channeled by the shapes of the roofs to two special water-handling features. In one case, the water will flow down a "water stair" to a garden where the soil will be prepared with porous materials to be especially receptive for absorbing water. In the other case, the water will flow down an outside wall (visible from the Quad) and then into a discharge area in the Quad that is again prepared to let runoff re-enter the groundwater directly. There is an additional lead from the Chemistry wing and the Harry Wood Garden that will go to a third discharge bed also in the Quad. There will be times when the rate of precipitation exceeds the capacity of the discharge beds; on such occasions the water will go to overflow tanks. The water in these tanks can be used for irrigation or slowly drain into the regular stormwater system. Additionally, the edge of the Woods will be protected by a buffer zone that channels runoff into the stormwater system rather than allowing it to erode the hillside (R. Merz, personal communication).

Large, contiguous forests on uplands, slopes and floodplains represent the best natural conditions for maintaining the hydrologic cycle and recharging water back into the ground, where the water table gradually supplies springs, wetlands, streams and trees with water year round. There is a growing realization among engineers and landscape architects that "naturalizing" stormwater management structures by replacing turf with native plants and looking to natural wetlands as design models can reduce installation

and long-term maintenance costs while enhancing aesthetic and environmental values. Swarthmore College, as an institution of higher learning, represents an ideal location to showcase innovative stormwater management practices as a model for the Crum Creek watershed and the region.

2.2.2 Healthy plant communities and wildlife habitats

In their roles as educational assets and as some of the last refuges for declining native biodiversity in southeastern Pennsylvania, different parts of the Crum Woods are not interchangeable. Areas differ greatly in species diversity, quality and diversity of habitats, presence of populations of rare or otherwise highly valued and pedagogically important species, abundance of invasive introduced species, and the degree to which the landscape is degraded or pristine. One of the primary purposes of this plan is to classify various parts of the Crum Woods according to their values and capacities for teaching, scientific research, sustaining significant remnants of the region's natural heritage, and maintaining the environmental quality of central Delaware County.

Parcels of land that are considered to have the greatest value for teaching, research, the contemplation and appreciation of nature, and maintaining ecosystem function are designated in this document as **Natural Areas.** Each Natural Area consists of two parts. The area occupied by the outstanding or unusual natural assets that are the reason for special designation is the **Natural Area Core**. Surrounding each Natural Area Core is a zone designated as a **Natural Area Buffer**. Natural Area Buffers consist of land that must be managed in particular ways to insure the long-term survival of the Natural Area Core's assets. Special treatment of Natural Area Buffers — either protection in an existing wild state or restoration of natural vegetation — is vital in order to maintain the integrity of the Natural Area Core. Because Natural Areas are not sustainable without both the Core and the Buffer, both zones are considered as equally important from the perspective of conservation and stewardship.

Four major sets of criteria have been used to classify particular areas of land in the Crum Woods as having special conservation value (Table 6). Land meeting any of the four major criteria should be regarded as conservation lands; however, lands that qualify as Natural Areas (the first criterion on Table 6) should be given highest conservation priority (see Figures 8 and 9). Intact Natural Areas are by nature irreplaceable. They have extraordinary value for teaching and for sustaining some of the last and best remnants of intact ecosystem function and biodiversity within the urbanized area of Philadelphia. They have taken centuries or thousands of years to reach their current state and, if significantly disturbed, cannot be expected to recover within a typical human life span. Land areas that meet any of the other three criteria (Table 6) also have high conservation priority but not as high as Natural Areas. If they were damaged or degraded by future expansion of College facilities, unlike Natural Areas their values could be mitigated in varying degrees by human intervention Any decision to encroach on conservation lands must be made with full recognition of the

trade-off: adequate mitigation is achieved only over long time periods and at considerable effort and expense.

Table 6. Criteria for appraising land units' conservation priority.

priority	type of area and defining criteria
highest	**1. Intact natural areas** • have high diversity of native species and of native communities • are relatively undisturbed by humans • feature outstanding or unusual natural assets (e.g., populations of species that are rare or otherwise of special interest; exceptionally high plant or animal species diversity; intact landscapes where human influence is unusually mild) • are ecologically significant at a regional scale (i.e., among the best remaining examples of native plant communities in Delaware County)
high or moderately high	**2. Regionally threatened or severely diminished natural landscape elements that provide important habitat for wildlife and other vital ecosystem functions such as aquifer recharge, flood control, sediment retention, erosion control, nutrient assimilation, and local climate regulation** • wetlands • forest interior (> 305 ft. [100 m] from nearest non-forest habitat) • meadows and shrublands dominated by native species • forested riparian buffers (within 75 ft. [23 m] of stream margins) **3. Forest stands maintaining integrity of large contiguous forest blocks** • consist of all parts of contiguous forest blocks at least 100 acres (40 ha) in size (except cul-de-sac projections less than 100 ft. [30 m] wide whose length from base to apex is double the average width or more) • are essential for preventing local extinction of forest-dependent native wildlife species **4. Areas with cultural significance** • historic and archaeological sites • arboretum collections and gardens

2.2.2.1 Mature and old-growth forest

The Crum Woods contain the best examples of mature, native forest remaining in Delaware County and some of the best in southeastern Pennsylvania. Martin Forest — leased by the College to the Delaware County Department of Parks and Recreation as part of Smedley Park — is an old-growth forest remnant and has been celebrated as

such for at least a century (Harshberger 1904). Its features include a mature hemlock-red oak-mixed hardwood forest (a rare, intact southeastern Pennsylvania occurrence of the famed "northern hardwoods" forest type) on a northwest-facing slope, a dense stand of mountain-laurel, dramatic cliffs and rock outcrops, and a bottomland grove of ancient trees, including 16 giant tuliptrees with trunks up to 5 ft. 7.7 in. (172 cm) in diameter. The forest just north of the Old Mill House near the dam off Yale Avenue has extraordinarily intact and undisturbed examples of two native forest types, dry oak-heath forest and dry oak-mixed hardwood forest. A potential "state champion"(largest known in Pennsylvania) scarlet oak was recently found on the forested slopes near the Clarke House, with a trunk diameter of 3 ft. 10.6 in. (118 cm) and height well over 100 ft. (30 m). There are hundreds of trees of a dozen or more species that are comparable in age and size throughout the Crum Woods.

2.2.2.2 Forest interior

Many plants and animals native to east-central North America are forest-interior specialists, unable to utilize the outermost zone of forest near the edge as habitat. The area inside a forest but near its edge is vulnerable to a host of detrimental outside influences, including increased wind, light and heat, decreased humidity, and the influx of seeds of invasive introduced species (Yahner 1988; Cadenasso et al. 1997, 2002; Pickett et al. 1999, 2001; Cadenasso and Pickett 2000, 2001). The part of the forest that lies more than 100 m (305 ft.) from the closest edge is regarded as functional forest interior for many of the forest-interior specialists that have not already been extirpated from the region (see Figures 8 and 9). The area that still meets this criterion in the highly fragmented landscape of suburban Philadelphia is scant. The protection of what remains is crucial for a host of species whose populations are barely holding on in this area. Many of them are bird species that have been in decline locally (see Appendix G) since the construction of the Blue Route (I-476).

2.2.2.3 Riparian vegetation

Under natural conditions in our region, the areas adjoining rivers, streams, lakes and ponds are protected by forested "riparian buffers." A riparian buffer made up of a mixture of native plant types — herbs, shrubs, and trees — filters out sediment and pollutants, stabilizes banks, mitigates stormwater flows, reduces water temperatures, and provides food for aquatic organisms. It also provides a protected habitat for wildlife to obtain water without being exposed to predators. The Chesapeake Bay Program (Chesapeake Information Management System 2001) describes these benefits in detail:

- **Filtering runoff**. Rain that runs off the land can be slowed and infiltrated in the forest, settling out sediment, nutrients and pesticides (nonpoint source pollution) before they reach streams and water bodies. Infiltration rates 10 to 15 times higher

than grass turf and 40 times higher than a plowed field are common in forested areas.

- **Decreased flooding**. In addition to slowing the flow of water into a stream, riparian buffers increase the ability of the stream's floodplain to retain water. Not only does this help prevent flooding, but because the water takes longer to reach the waterway, groundwater recharge increases as well.

- **Nutrient uptake**. Fertilizers and other pollutants that originate on the land are taken up by tree roots. Nutrients are stored in leaves, limbs and roots instead of reaching the water. Through a process called "denitrification," bacteria in the forest floor convert nitrate to inert nitrogen gas, which is released into the air.

- **Canopy and shade**. The leaf canopy provides shade that keeps the water cool, retaining more dissolved oxygen, and encourages growth of diatoms, nutritious algae and aquatic insects. The canopy improves air quality by filtering dust and other wind-borne pollutants created by construction, farming, industry, and vehicles.

- **Food**. Leaves fall into the water and are trapped on woody debris (fallen trees and limbs) and rocks where they provide food and habitat for native bacteria, fungi, and small bottom-dwelling animals, organisms that are critical to the aquatic food chain.

- **Habitat**. Streams that travel through forests provide more and better habitat for aquatic organisms. Streams within forests are wider, providing greater bottom surface area for macroinvertebrates (mayflies, stoneflies, etc.). More food and cooler water, in turn, improves habitat for fish and the birds (herons, egrets, osprey) that feed on them. Woody debris serves as cover for fish while stabilizing stream bottoms, thereby preserving habitat over time.

- **Migratory corridors**. Forest corridors provide crucial migratory habitat for neotropical songbirds, some of which are now threatened due to loss of habitat.

2.2.2.4 Wetland communities

Wetlands provide ecosystem services out of proportion to their usually small area, including aquifer recharge, flood control, sediment retention, nutrient assimilation, and habitat for the highest diversity of wildlife species of any of the region's natural communities. An estimated 56% of Pennsylvania's original wetlands were destroyed between the 1780s and 1980s (Dahl 1990); the losses were even higher in heavily urbanized southeastern Pennsylvania. Wetland destruction continues despite federal legislation intended to halt the net loss of wetlands, although the rate of loss slowed in the last decades of the twentieth century. The Crum Woods include 29.7 acres (12.0 ha)

of swamps, marshes and floodplains, which are still fairly intact and species-rich despite a history of filling, debris dumping and other misuse.

2.2.2.5 Wildlife habitat

A systematic inventory of wildlife species other than birds (Williams et al. 1999; see Appendix G) has never been undertaken, but it is clear from observations over the years by biology faculty, students and local naturalists that the remaining forests and wetlands provide habitat for many species that would undoubtedly have disappeared from the area if the Crum Woods had been further reduced in size. The Crum Woods provide some of the last remaining habitat in central Delaware County for animal species that require unbroken blocks of forest to survive, breed and raise offspring. Often called forest-interior wildlife species, they are highly vulnerable because they are sensitive to forest fragmentation. Many of them are birds, including red-eyed vireo, wood thrush, ovenbird, great crested flycatcher, and eastern wood-pewee. The Woods also include several outstanding wetland complexes featuring a variety of wildlife habitats critical to a set of animal species that is generally declining in our region as wetlands continue to be destroyed. One of these, Skunk-cabbage Hollow, is an unusually prolific stopover site for migrating songbirds. The Woods also straddle or have frontage on 2.1 mi. (3.4 km) of Crum Creek and 0.8 mi. (1.3 km) of other perennial streams, which harbor two dozen fish species and hundreds of other aquatic animals including turtles, frogs, salamanders, large predaceous beetles and dragonfly larvae, clams and a freshwater sponge.

Janet Williams, Senior Research Associate (now retired) in the Department of Biology, and her students in Ornithology (BIOL 032) conducted systematic bird surveys each spring for five years (1996, 1998-2000, 2002). Three hundred eighty-eight hours of observation produced a tally of 14,337 birds of 107 species (Kight 2003). In an analysis of a subset of the data (Kight 2003), the most striking result was the mismatch between the fractions of Crum Woods land area in certain habitat types and the fraction of bird species estimated to be utilizing it.[8] For example, marshes and shrub swamps together comprise 1.5% of the total Crum Woods' land area, yet, combined, these areas likely support nearly 10 times that proportion of the Woods' total bird species (14% of all common bird species seen in the Crum Woods). Similarly, upland thickets (shrub-dominated areas) make up only 1.9% of the Crum Woods but are estimated to support a seven-times-higher (13%) proportion of the Woods' bird species. (Such data suggest that removal of large amounts of invasive shrubs without replanting would negatively impact bird life. In fact, 80% of all species that showed declining trends over time were species that require dense shrubs or other thick cover.) Floodplain forests and woodlands (14% of the total Crum Woods land area) likely support double the

[8] Each bird species observed regularly in recent years in the Crum Woods ($N = 84$) was assigned to one or more broad categories of habitat (deciduous forest/woodland, coniferous forest/woodland, mixed forest, upland thicket, marsh/shrub swamp, meadow/turf) based on published data pertinent to species' habitat preferences in the region (Kight 2003).

proportion of bird species that would be predicted by area alone. Another way of looking at this phenomenon is to compare habitat types in terms of the number of species present in the Crum Woods per acre (0.4 ha) of each habitat type. Marshes are habitat for more than twice as many species per acre, about 19, as the second-richest habitat type, coniferous forests and woodlands, which likely host around 9; upland thickets were third-richest with just over 4 species per acre and other forests, woodlands, and mowed turf had less than 2. Habitat types had the same rank order with respect to the habitat preferences of uncommon bird species seen in the Crum Woods: approximately 2.4 uncommon species per acre in marshes, 0.7 in coniferous forests and woodlands, 0.6 in upland thickets, and less than 0.3 in other forests, woodlands, and areas of mowed turf.

Birds are one of the most conspicuous wildlife groups in the Crum Woods for study and recreational activities (bird watching). Janet Williams's data and the subsequent analysis (Kight 2003) have provided useful predictions and guidelines for areas that should have highest priority for habitat conservation. For example, clearly the small area of marshland is disproportionately important in sustaining high bird species diversity in the Woods. Maintaining or restoring marshes where non-marsh plants are invading or have already supplanted native wetland species should deliver a significant, highly visible return for a relatively modest investment of funds and time. The bird study also highlights the disproportionate importance of coniferous forests and woodlands, which are currently in decline in the Crum Woods due to attacks by an introduced insect pest (hemlock woolly adelgid), and thickets, which represent a temporary, successional stage in vegetation development and require active management if they are to persist. At least one bird species dependent on thickets, the eastern towhee, is apparently declining in the Woods, decreasing in the surveys from an average of 3 birds per 10 hours observation time in 1996 to 0.4 in 2002 (Kight 2003). These studies have also established when and where disturbance to birds should be minimized, namely spring and summer in all habitats, areas of thick shrubs (including invasive species) especially in wetlands, and meadows. The ranking for birds may also apply in varying degrees to other animal groups, as birds can provide a useful index of overall habitat quality.

2.2.2.6 Uncommon and threatened species

The forest north of the Old Mill House harbors an original stand of southern red oak, *Quercus falcata*, a tree classified as endangered in the state (Pennsylvania Natural Diversity Inventory 2001). Three other plant species ranked as endangered, threatened or rare in Pennsylvania were collected in the Crum Woods and preserved in the college herbarium, but have not been seen in recent years (Appendix F). It is not known whether they have survived to the present day. Plant species occurrences of regional significance include native stands of trailing arbutus, *Epigea repens*, Canada yew, *Taxus canadensis*, purple trillium, *Trillium erectum* and large-flowered trillium, *T. grandiflorum*,

and mature, apparently native occurrences of honeylocust, *Gleditsia triacanthos*, balsam poplar, *Populus balsamifera*, and chestnut oak, *Quercus montana*.

Twelve bird species on Pennsylvania's species of special concern list were seen in the Crum Woods in the late 1970s, 1980s and early 1990s (see Appendix G; Williams et al. 1999; Pennsylvania Natural Diversity Inventory 2001). They are American bittern, great blue heron, osprey, bald eagle, northern harrier, northern goshawk, peregrine falcon, northern bobwhite, common snipe, long-eared owl, Swainson's thrush, and prothonotary warbler. About half of these are year-round residents in the region, using the Woods occasionally for resting or feeding; the rest spend the winter in the area or stop over during migration. None is known currently to breed and raise offspring in the Crum Woods. Sightings of two of them, Swainson's thrush and prothonotary warbler, have been declining in recent decades in the Crum Woods (J. Williams, personal communication). Nevertheless, a strong protection and restoration program could result in sufficient habitat improvement to enable recovery and perhaps to attract and sustain one or more of them as local breeding residents again. The Woods also are known to provide homes or migratory resting-places for 11 bird species on the National Audubon Society's "WatchList" of species at highest risk of becoming endangered (National Audubon Society 2002). They are American woodcock, bay-breasted warbler, Bicknell's thrush, Canada warbler, Kentucky warbler, prairie warbler, prothonotary warbler, rusty blackbird, worm-eating warbler, blue-winged warbler, and wood thrush. Of these, blue-winged warbler and wood thrush have been documented as nesting in recent decades in the Crum Woods (Williams et al. 1999) and are probably still breeding residents.

Other locally significant animal species include the grapevine epimenis, *Psychomorpha epimenis* — a daytime-flying black, white, red and iridescent blue moth — and a very large hawkmoth, Franck's sphinx, *Sphinx franckii* (T. Valente, personal communication). Two giant beetles found in the Crum Woods, the stag beetle, *Pseudolucanus capreolus* and bess beetle, *Odontotaenius disjunctus*, depend on mature and old-growth forest for the rotting logs that provide their food, shelter and breeding sites (T. Valente, personal communication).

The exceptionally intact forests and wetlands of the Crum Woods are prime sites for the reintroduction of species that disappeared locally due to forest clearcutting, agricultural runoff, severe stream pollution, and the unregulated use of pesticides before the 1970s. Examples include the redbelly turtle *(Pseudemys rubriventris)*, a threatened species in Pennsylvania, spotted salamander *(Ambystoma maculatum)*, red-spotted newt *(Notophthalmus viridescens viridescens)*, gray treefrog *(Hyla crysocelis)*, northern black racer *(Coluber constrictor constrictor)*, northern ringneck snake *(Diadophis punctatus edwardsii)*, black rat snake *(Elaphe obsoleta obsoleta)*, large yellow lady's-slipper (*Cypridepium calceolus* var. *pubescens)*, and hobblebush *(Viburnum lantanoides)*.

3.0 Threats

Threat analysis consists of the identification, evaluation, and ranking of stresses and sources of stress that affect each of the conservation priorities. The subjects of threat analysis are stresses that impact species and communities directly or indirectly, including those that alter ecological processes, and the sources of those stresses. Stresses may be defined as processes or events with direct deleterious ecological impacts. Sources of stress are actions (or instances of inaction) and the entities that carry them out. The distinction between stresses and sources of stress is not strictly dichotomous; there is a continuum between stresses, which affect conservation targets most directly, and their sources, which extend outward in a chain of causality, often ultimately to the various, often competing demands of the still-growing human population.

Threat assessment is a vital part of effective site conservation planning. The presence and impact of threats is key information for determining Natural Area boundaries, management needs, stewardship strategies, and their costs and feasibility. Likely potential threats, as well as current threats, must be identified, evaluated, and ranked, and the process must be a team effort, with participation by a range of stakeholders to insure that different points of view and sets of knowledge are included. Threat analysis must be an ongoing and iterative process. Not every likely potential threat can be anticipated at the outset. Part of an effective conservation plan is to provide the institutional means to identify and evaluate new threats promptly as they arise and to adjust stewardship strategies as old threats wane.

3.1 THREATS TO PROGRAMMATIC PRIORITIES

3.1.1 Potential loss of educational assets

Further fragmentation of the contiguous forest area would result (depending on the magnitude) in the decline or local extinction of animal species, especially birds. The continued spread of introduced invasive plant species would result in losses of plant and animal species and the homogenization of the diverse natural landscape into an impoverished one, permeated by what has been aptly termed “biological pollution.” Such scenarios depict substantial losses in opportunities for teaching, field study, and

research in ecology, plant systematics, animal behavior, ornithology and other biological subject areas.

3.1.2 Potential lapse in stewardship

The College strives to instill its students with a high degree of social responsibility. Dedicating resources to properly steward the Crum Woods would set a creditable example for its students and assist them in realizing "a deep sense of ethical and social concern." Indeed, few communities can remain viable and attractive places to live without proper stewardship of the natural environment. In lieu of the "virtual" discussions found at any college, this represents an opportunity for "real-world" learning. The College has the opportunity to highlight the disproportionately large role the College's land and biological resources play in sustaining the environmental and recreational quality of the wider community and in preserving some of the best remaining natural heritage sites in the region.

3.1.3 Potential decline in recruitment value

Williams College and several other highly ranked liberal arts colleges in the United States own adjacent or nearby forest tracts and other natural areas (see Northeastern examples in Table 5). Most are larger than the Crum Woods and some are widely known as showpieces of research and curricular use. Neglect of the Crum Woods' growing problems or avoidable losses of teaching and research opportunities could be detrimental to Swarthmore's competitive edge in attracting top students and sustaining a strong academic reputation.

3.2 THREATS TO FOREST AND WILDLIFE HABITAT INTEGRITY

3.2.1 Fragmentation

Fragmentation is second only to outright destruction and conversion of forestland to other uses as a cause of degradation of ecosystem function, habitat quality, and biodiversity. Forest fragmentation results in the local extinction of species and can lead to far lower overall species diversity than would occur if the same total area of forest were to remain as a single contiguous block. For many animal species, the area of contiguous habitat in a forest fragment must be above some threshold size for a population to sustain its viability for more than a few years (Whitcomb et al. 1981; Hollingsworth 1988; Temple and Cary 1988; Yahner 1992, 1997, 1998; Robbins et al. 1989; Porzeluzi et al. 1993; Hoover et al. 1995; Robinson et al. 1995; Gibbs 1998; O'Connell et al. 1998, 2000).

Minimum-area requirements vary greatly among species, but the total area of forest in a fragment is not all that matters. Many plants as well as animals are forest-interior

specialists, unable to utilize the outermost zone of forest near the edge as habitat. The area inside a forest but near its edge is vulnerable to a host of detrimental outside influences, including increased wind, light and heat, decreased humidity, and the influx of seeds of invasive introduced species (Yahner 1988; Cadenasso et al. 1997, 2002; Pickett et al. 1999, 2001; Cadenasso and Pickett 2000, 2001). In general, fragmentation favors invasive species and works against native species.

Furthermore, the threshold size of a forest block required to sustain a population of a forest-interior species is larger with greater isolation from other forest blocks. Consequently a long-established population in a forest fragment may die out even if the habitat remains intact, if enough nearby forest fragments are further fragmented or destroyed. Put another way, in a neighborhood in which most of the forest is gone, the remaining forest fragment must be larger to sustain the same level of species diversity than if it were near other large forest blocks.

Fragmentation has at least four components:

- reduction in total forest area
- reduction in the area that functions as forest interior
- increase in the edge-to-area ratio
- increased isolation from the nearest large forest blocks

Conventionally, in temperate eastern North America the part of the forest that lies more than 100 m (305 ft.) from the closest edge is considered as functional forest interior for most species. It follows that, in two forest blocks with identical areas but different "footprints," the one with the higher edge-to-area ratio (i.e., more sinuous edge or narrower overall shape) is more fragmented. A circle is the two-dimensional shape with the lowest edge-to-area ratio and hypothetically the optimal shape for conserving forest diversity in a fragment, but smaller circles have higher edge-to-area ratios than larger circles. Any part of a forest block whose width is 200 m (610 ft.) or less has no functional interior. Cutting a road or other linear non-forest feature through a forest fragment may not decrease total forest area by much, but the two fragments so created each has a much smaller maximum area, a much higher edge-to-area ratio, and far less (or no) functional interior.

In central Delaware County, fragmentation has been severe. The Crum Woods have already lost many species once known to occur there. It takes years or decades after an increase in fragmentation before all of the species most affected finally die out. The most devastating blow in recent years occurred when the Blue Route (I-476) was built. There is little doubt that a series of local species extinctions, especially of birds, has

resulted from the decreased area of the contiguous forest block and that the ripple effect will continue for some time to come.

The source of fragmentation is conversion of forestland to other uses. Housing development and highway construction are responsible for much of the 30% loss in area of the Crum Woods' contiguous forest block since the first aerial photos were taken in 1937. In recent decades, the College itself has been responsible for some of the increased fragmentation. Over the last 30 years each of these construction projects in turn took a bite out of the Campus Woods: Crum Ledge faculty apartments, Dana and Hallowell dormitories, Lang Music Building, Cornell Library, the road link behind Cornell Library, the water tower parking lot, the Mullen Tennis Center, and most recently the air conditioning plant for the new Science Center.

3.2.2 Invasive plant species

Only a small minority of introduced species have proven to be invasive in our region, but their destructive impact on native biodiversity is exceeded only by direct habitat destruction and fragmentation. An invasive species is one that rapidly spreads and outcompetes multiple native species, in all likelihood chiefly because of the absence of the predators, pathogens and herbivores that keep it in check in its homeland (Wolfe 2002; Mitchell and Power 2003). By displacing native vegetation, invasives homogenize and greatly simplify the structural and food resources of a site, reducing its habitat value for native fauna, particularly migratory songbirds.

Historically, land use in the region was dominated by agriculture and logging. Those uses coupled with recent residential and commercial development have effectively removed most of the native vegetation in the region and, through land parcel subdivision and clearing, added countless miles of edge to the fragments of forest that remain. Forest edges are highly favorable to the entry and proliferation of invasives. The misguided promotion of several exotic species for erosion and livestock control and widespread horticultural plantings have established ubiquitous seed sources and allowed many invasive species to sweep through the region's remnant forests.

Some invasive species are more destructive to native species diversity than others. For example, an individual Norway maple, *Acer platanoides*, exterminates nearly all North American native species in the entire area beneath its canopy (Wyckoff and Webb 1996). The species tolerates shade and the other competitive effects of our native trees so well that it is spreading through the Crum Woods and other forests in the region, annihilating native biodiversity almost as effectively as a moving glacier (Webb et al. 2000). Mile-a-minute, *Polygonum perfoliatum*, on the other hand, spreads faster than Norway maple but its effects are most prominent in areas that have been disturbed by human activity, for example, farm fields, bulldozed land or forest clearcuts. It is not a threat to most forested Natural Areas, but can be a severe pest in shrub-dominated or herbaceous communities (Hill et al. 1981; Mountain 1989).

Sources of invasive species include seeds spread via birds, wind, or water from areas with established populations of invasives. Some spread clonally (vegetatively) by rhizomes or runners from ornamental plantings on landscaped areas that lie adjacent to the forest. Recently, the Scott Arboretum has endeavored to identify the plant species that are invading the Campus Woods and remove them from campus plantings. However, at least 13 severely invasive plant species are well established in the Woods and more than two dozen other introduced species also are expanding (see Figures 6 and 7; Appendix J, Tables J1 and J2). These populations are the chief sources of seeds and the many advancing fronts of clonal spreading that threaten plant diversity in the Woods.

At this time, the most problematic species within the Crum Woods include Norway maple, Japanese knotweed and privet, along with several groundcovers (English ivy, Japanese honeysuckle, Japanese pachysandra, five-leaved akebia) and vines (oriental bittersweet, mile-a-minute, grape). The Norway maple is spreading within many of the management units and, along with deer browse and the invasive groundcovers, discouraging the establishment of native tree and shrub regeneration. Privet and Japanese knotweed are monopolizing the shrub layer within the valuable riparian areas along Crum Creek. The invasive vines are generally limited to the forest edges and trees along Crum Creek, but their growing presence within canopy gaps in the forest adjacent to the Holly Collection is a harbinger of future conditions within all of Crum Woods sans invasives control. It should be noted that while invasive vines pose a significant threat to the forest, there are native vine species within Crum Woods that have high food value for wildlife. Poison ivy, Virginia creeper and grape should not be cut from trees until they begin to seriously compromise the health of the tree. Usually, this only happens with grape, which can eventually overtop the canopy of the tree. At this point the grape should be cut, but not treated with herbicide so that it can resprout. Appendix J provides a general strategy for addressing this issue along with techniques for controlling specific types of plants.

3.2.3 Deer overabundance

Ecosystems have responded to human activity over the past several centuries in some unforeseeable ways. For example, forest fragmentation, the extirpation of large predators, and cultural norms about hunting have resulted in the proliferation of one disturbance-adapted herbivorous animal, white-tailed deer, *Odocoileus virginianus*, to unprecedented population densities. This has resulted in the collapse of plant species diversity in the forest understory and the near cessation of tree reproduction in vast areas of Pennsylvania forests. Immense tracts of northern hardwood forest in northern Pennsylvania have a near monoculture in the understory of just two native fern species, hay-scented fern, *Dennstaedtia punctilobula*, and New York fern, *Thelypteris noveboracensis*. They are unpalatable to the deer and allelopathic, that is, they have chemical and physical properties that bring about a near-total inhibition of the growth of other plants, including tree seedlings. The loss of the shrub layer to deer browsing

has magnified the decline in forest bird species already brought on by forest fragmentation, in turn reducing predation on insects including outbreak tree-eating species such as the elm spanworm, *Ennomos subsignarius*, and forest tent caterpillar, *Malacosoma disstria*. Deer population densities have apparently exceeded a critical threshold allowing rapid expansion of the population and range of the deer tick, *Ixodes scapularis*, which in turn has given the once highly localized Lyme spirochete, *Borrelia burgdorferi*, the chance to explode into an epidemic in several mammalian host populations, including humans.

The threat to the Crum Woods is profound. The current deer density is already high enough that tree seedlings are virtually absent from the forest floor. Some seedlings do manage to establish, especially following years of strong acorn production, but they are thoroughly browsed and eradicated in a year or less. Native oaks, which are highly preferred food for deer, are not regenerating, which means that the wildlife-rich oak forests will cease to exist as adult trees age and die. Although there is regeneration above browse height in most canopy gaps of a few species less preferred by deer, the number of seedlings is barely adequate to fill each gap, which leaves no margin for future adverse impacts. Regeneration of each gap will hinge on these few seedlings surviving a host of stresses (buck rubs, invasive vines, drought, insects, windthrow) on their way to the canopy. Other signs of an increasing deer density include a clear browse line in the upper slopes of Martin Forest and the Southern Red Oak Natural Area, and the general dominance of spicebush (a plant not preferred by deer) in the native shrub component of Crum Woods.

The Woods still have a diverse array of spring ephemeral wildflowers, which burst out of the ground in a massive flush in April and wither back to dormancy by June, but the diversity of native herbaceous plants that normally persist through the summer and fall is relatively low. The native species diversity that makes the Crum Woods so valuable as a teaching resource and as a healthy, functioning ecosystem in the midst of suburbia will continue to decline if the deer density persists at current levels. It will decline precipitously if deer density increases.

The current overabundance of white-tailed deer and its pervasive effects on the rest of the ecosystem must be considered in light of the species' coexistence with a diverse array of predators (including timber wolf, dire wolf, Armbruster's wolf, grizzly bear, giant short-faced bear, mountain lion, American cheetah, Studer's cheetah, and jaguar) for more than 99% of its existence in Pennsylvania and the surrounding region. The source of the problem is the human-caused extinction of top predators and fragmentation of the forest (white-tailed deer is an edge specialist, not a species of the forest interior). Ironically, today *Homo sapiens* is the only species left in the area capable of maintaining the population density of white-tailed deer low enough to keep them from stripping the forest like locusts (Appendix I provides recommendations for controlling deer populations). Deer have multiplied across most of eastern North America to densities far in excess of the maximum for sustaining a healthy forest

because human predation, as it is currently practiced by hunters and regulated by state wildlife agencies, differs both quantitatively and qualitatively in key ways from the predation that regulated deer numbers throughout the species' evolutionary past.

3.2.4 Adverse uses

Recommendations pertaining to the type, character, and amount of human use are based on the impact each use has on the conservation priorities for a given area of land. The following is a review of current uses and their existing and potential adverse impacts.

3.2.4.1 Walking/hiking on trails

From a purely natural resource perspective, trails and roads have detrimental effects on the forest, both ecological (creating migration barriers and "killing fields" for certain organisms) and environmental (forming channels for stormwater). In addition, human users of trails can unknowingly carry seeds of invasive plants into pristine areas. However, given that recreational use of the Crum Woods by the College community is a relatively high priority, trails are the best way to direct that use. The main concerns with walking trails are (1) limiting the number of trails to minimize soil exposure, (2) properly routing trails to direct pedestrians through and to where they should go and away from where they should not go, and (3) minimizing soil erosion potential through proper construction and maintenance.

3.2.4.2 Bikes

Bicycles can be relatively benign in natural areas under certain conditions (large area, low frequency); however, they are problematic if the activity is concentrated and in mixed-use situations. Repeated use of trails can accelerate trail erosion by funneling stormwater into narrow, continuous channels. Off-trail exploration disturbs understory plants and wildlife. Most importantly, bikes threaten both the safety and recreational enjoyment of pedestrians.

Assuming that recreational walks by students, faculty, and neighbors top the list of non-pedagogical uses for the Crum Woods, the current level of bike activity should be reduced or eliminated. The current type and level of use has created conflicts with walkers, degraded trails, and disturbed off-trail vegetation. As a compromise and as a way for members of the College community to use bikes as a recreational activity, a bike route could be established in the area from Crum Ledge to the railroad trestle. In this area the trails are level or are on old roadways and, therefore, will be more resistant to bike wear. If the bike users do not respect the location of the trail and other conditions (speed limits), the College should prohibit bikes in the Woods.

3.2.4.3 Dog walking

People walking leashed dogs can be a compatible use of the Crum Woods if it is limited to the established trail system and the owners clean up after their pets. Unleashed dogs are not a compatible use given the higher academic, ecological, and recreational priorities for the Crum Woods. Unleashed dogs threaten the safety and recreational enjoyment of other users. They often harass and kill wildlife and disturb understory vegetation. The College should establish a pet policy that protects visitors and natural resources and inform the community through appropriate signage. If visitors refuse to comply with the policy, the College should consider revoking this privilege.

3.2.4.4 Material and equipment storage and disposal

Several locations within the Woods are being used for the storage and disposal of various building and landscaping materials. The most significant of these adjoins the core of the Southern Red Oak Forest Natural Area next to the composting facility operated by Nether Providence Township and the Borough of Swarthmore on College land, west of Crum Creek across from Strath Haven Condominiums (Figure 18). The open ground along the composting facility's perimeter and the adjoining forest edge are used as a dumping ground for stone, concrete waste, discarded metal scrap, and the wood generated by the removal of hazardous or diseased trees from throughout the Arboretum.

An old, inactive debris dump sprawls across part of the Skunk-cabbage Hollow Natural Area, in the middle of its Core section (Figure 18). The disturbed soils are heavily infested with introduced invasive plant species, some of which have spread into the surrounding, intact sections of the wetland and threaten the integrity of this exceptionally high-diversity native wetland community. Smaller areas of scattered debris also exist in the Oxbow Swamp, Wister Forest, and Martin Forest Natural Areas (Figure 18).

The remaining dump sites are scattered along the perimeter and are created by numerous people (staff, volunteers, contractors, renters in College-owned houses, and adjoining landowners) for convenience to dispose of debris from the adjoining landscaped area. Some of the sites are created ad hoc to discard downed trees; most are established sites for the disposal of debris from repeated activities (lawn mowing, pruning, leaf collection).

Stockpiled and discarded materials and organic waste are unsightly, potential hazards to human visitors and wildlife, and often become overgrown by invasive vegetation. These areas can then act as a source of seed and vegetative spread, fostering further invasion into nearby natural areas.

Building materials that have potential future use should be consolidated in a more appropriate location — one away from critical natural resource and public use areas. Waste material should be disposed of properly, either in a landfill or, if possible, used as clean fill in on-site construction projects.

We recommend that the ongoing practice of using the forest edge as a disposal site for organic waste (grass clippings, pulled weeds, pruned branches, tree boles) be discontinued. While it may appear to be a benign, perhaps even beneficial, means of disposal, this practice can pose a real threat to the health of the forest. Such materials are foreign to the forest ecosystem and behave very differently from forest litter-fall or tree-fall debris. They bear non-forest seeds, insects, fungi, bacteria, and chemical properties, some of which can cause harm to native forest species. They are invariably placed in piles or thick layers and take much longer to decompose than the thin veneers of litter that are laid down naturally by forest vegetation. These piles severely inhibit the establishment of native forest-floor plant species from seed, including tree seedlings, but they typically do provide favorable conditions for many introduced invasive species. Under no circumstances should wood or other organic debris from tree-cutting, pruning, weeding, mowing or any other activity outside of the Woods be disposed of by dumping it in or adjacent to any part of the Woods by facilities and Arboretum staff members, volunteers, contractors, renters in College-owned houses, and adjoining landowners.

3.2.4.5 Paintball games

Even though the paint used in this activity is, in some cases, environmentally benign, paintball games cause damage to understory vegetation, harass wildlife and, in the end, leave an unsightly mess. In mixed-use situations paintball games can be hazardous and disturbing to other users. This activity is inappropriate for the Crum Woods.

3.2.4.6 Fires

Fire was a force that greatly influenced the development of most of southeastern Pennsylvania's forests and, if employed judiciously and under the strictest safety procedures, it would no doubt be ecologically beneficial to certain parts of the Crum Woods. However, fire also has the potential to be highly destructive, particularly in an urban setting. Because the Crum Woods are in an urban setting, fire will probably have very limited use, if any, as a management tool. Its use for "recreational" purposes should be highly controlled as well to prevent escapes in this urban interface. Under Pennsylvania law, the person setting a fire is responsible for any damage that results from that fire. Any fire created with the knowledge and consent of the College might convey some liability to the College for any damages caused by an escape from that fire. The newly instituted permitting system for students wishing to make bonfires in Crum Meadow (see Section 1.4.2.4) includes safety precautions that will help to prevent such escapes.

3.3 THREATS TO STREAM WATER, AQUATIC COMMUNITY, AND SOIL INTEGRITY

The Crum Woods sit squarely in the lower half of the Crum Creek watershed, and it is the surface water and groundwater of this watershed that cycles through the bedrock, soils, vegetation, and wildlife and sustains the life that characterizes the Crum Woods. The Crum Woods landscape is directly influenced by the quality and quantity of water that constitutes the system of streams, wetlands, and groundwater in the area. Potential threats to the quality and quantity of water in the Crum Creek watershed, therefore, also represent potential threats to the Woods ecosystems. The creek and its tributaries are themselves vibrant ecosystems teeming with aquatic life whose health depends on the quality and rate of runoff from the entire watershed.

There are no obvious and immediate sources of threat in the watershed upstream from or surrounding the Crum Woods that could cause instant, widespread contamination of Crum Creek or the associated groundwater aquifers. However, with the advance of technology, we have the ability to alter the landscape more rapidly and at a broader scale than ever before. The more we clear native vegetation, excavate and compact soil, and construct impervious surfaces such as rooftops and parking lots, the more we "short-circuit" the natural hydrologic cycle that recharges aquifers, regulates flooding, and feeds wetlands and streams with clean, plentiful water to support plant, animal, and human needs (including vital drinking water supplies).

When we consider the root causes behind the degraded quality and diminishing quantity of water in the Philadelphia region and the severity of flooding and threats to life and property, all evidence points to **urban development** and **lack of proper stormwater management** as the major culprits. The primary threat to water quality and quantity in the Philadelphia region is non-point-source pollution, which consists primarily of polluted stormwater runoff from urbanized areas and agricultural fields (in contrast to point-source pollution, which is discharged from pipes at industrial facilities or sewage treatment plants). The major cause of dangerous flooding is directly linked to urbanization, as we pave over watersheds and allow most of the stormwater runoff to head directly into streams rather than recharging into the soil as it would do naturally. The suburban land-use pattern of the Crum Creek watershed favors seemingly benign single-family residential neighborhoods and shopping centers rather than large industrial manufacturing facilities or hazardous waste facilities. However, the construction sites, roads and parking lots, lawns and sewage systems of this deceptively tame suburban landscape are responsible for the greatest threats to water quality and quantity in the watershed.

3.3.1. Suburban land-use impacts to water quality

An Assessment of the Crum Creek Watershed, Including Springton Reservoir (Schnabel Engineering 2001), an inventory of potential threats to the drinking water supply, found

that "the level of sediment and phosphorus loading is unacceptably large within the watershed" and that "the watershed and reservoir are under considerable stress imposed by a quickly developing watershed." The assessment evaluated 56 potential contaminant sources that could affect the Philadelphia Suburban Water Company's Crum Creek reservoir system, which serves over 300,000 customers. The findings provide important insight on the potential threats from upstream locations affecting water resources in the Crum Woods.

Sediment and phosphorus are examples of non-point-source pollution. Sediment is generated by storm runoff and associated soil erosion from farm fields, construction sites, roadways, parking lots, lawn areas, and eroding stream banks. Excessive sediment in streams can inhibit fish reproduction by smothering eggs, and can harm other aquatic life, particularly bottom-dwelling species. The chronic erosion and sedimentation problems facing the Crum Creek watershed can be attributed to its high percentage of residential and commercial development with few effective systems for retaining and recharging stormwater.

Phosphorus is often contained in runoff from lawns and gardens using chemical fertilizers and can be found in household and commercial detergents, which enter the creek through wastewater systems. Phosphorus is the main nutrient responsible for eutrophication (nutrient enrichment, which causes algae blooms) in waterways. As algae decompose, they consume dissolved oxygen and diminish the ability of the creek to support healthy populations of fish and other aquatic life.

Additional threats to the quality of both surface water and ground water resources include:

- Chemical or oil spills on roads, with direct drainage to the tributaries or the main stem of Crum Creek, particularly near numerous road crossings and the lengthy overpasses of the Blue Route (I-476) where tanker truck accidents are a possibility.

- Chemical or oil spills, leaks or dumping associated with commercial operations such as dry cleaners, golf courses or gas stations, underground storage tanks, and even careless homeowners. A vehicle maintenance facility located close to the Lower Crum Reservoir is also a potential source of contamination associated with volatile organic compounds.

- Sewage treatment plant malfunctions or overflows, with the potential to release large amounts of disease-causing bacteria, nutrients, and heavy metals.

- Overpopulated waterfowl (particularly Canada geese) in the Lower Crum Reservoir and area ponds, due to high levels of fecal coliform bacteria and nitrogen associated with goose droppings.

- Agricultural runoff from pastures and crop fields lacking adequate riparian forest buffer coverage along streams, which is still a significant source of nutrient, silt, and pathogen contamination in Crum Creek.

3.3.2 Suburban land-use impacts to water quantity

The agricultural, suburban, and urban land-use pattern of the region, including the Crum Creek watershed, has altered the natural balance of ground- and surface water that defined the forested landscape prior to William Penn's arrival in 1682. Almost the entire watershed has been cleared of forest, plowed and grazed for agriculture, bulldozed for development, planted in lawns, or paved. Each of these actions generates unnatural rates and amounts of stormwater runoff, particularly in the wettest periods of the year. Water that once infiltrated soil and recharged aquifers to gradually feed wetlands and streams during periods of drought is now lost downstream to the Delaware Bay and Atlantic Ocean. As a result, the frequency and extent of flooding is artificially high, and the water table that allows groundwater to feed wetlands and supply the base flow of streams is artificially reduced to unnaturally low levels during the driest periods of late summer.

Decreased groundwater levels are manifest in wetlands and small streams in the Crum Woods that become drier earlier in the year than they did in the past, and in resulting changes in the plant and wildlife populations. For example, invasive species such as Japanese honeysuckle and multiflora rose have become dominant in many former wetland areas, and salamander populations reliant on vernal pools (small areas of standing water, normal in springtime) for breeding have declined or disappeared for lack of habitat.

In sum, the quality and quantity of surface and groundwater and the ecological integrity of the Crum Woods are closely interrelated. Increased surface runoff generated by poorly planned development results in increased flooding and erosion, diminished groundwater levels, increased pollution of ground- and surface water, increased concentration of pollutants, and reduced diversity of native plants and wildlife.

3.3.3 Erosion and compaction

Most of the soils underlying Crum Woods originate from the schists of the Wissahickon Formation. Being located primarily on moderately to very steep slopes, these soils tend towards instability and are subject to serious sheet and gully erosion, especially in areas without vegetative cover.

The Crum Woods experiences the effects of increased runoff and flooding through erosion and sedimentation in the main stem of Crum Creek and its tributaries, particularly where unnaturally large sediment deposits form large sandbars or islands, and where severe bank erosion and gully erosion is evident. Effects of this trend on

vegetation and wildlife in the Crum Woods can include premature mortality of trees undermined by eroding streambanks and decreased diversity of stream-dwelling organisms.

Trails are essential for proper management and recreational enjoyment of natural areas, but if poorly designed or misused they can become stormwater channels that cut into hillsides and remove organic and inorganic soil components. In severe cases, gully erosion can lower the water table and stress established vegetation. The trail system that has evolved in the Crum Woods effectively serves the management and recreational needs of the college community and in general is not a source of active soil erosion. There are, however, areas where trails are a threat to soil resources, mainly due to poor (or nonexistent) design. In these areas trails run more or less directly down the slope because it is the most direct route between two points.

Users (hikers, mountain bikers) of the Crum Woods continue to create trails as the need or inspiration arises. This not only results in the formation of potential erosion channels, but tramples understory vegetation and expands the amount of compacted soil within the Crum Woods. Compacted soil results in lower water percolation and soil gas exchange — both detriments to forest trees and shrubs.

In some areas (for example, the northwest corner of Martin Forest and the southwest portion of the Campus Woods) invasives are adding to the potential for soil erosion. Invasive trees, particularly Norway maple, create such a dense shade that the soil surface is essentially devoid of shrubs and herbaceous plants, leaving little soil protection and none at all where part of the canopy is removed by wind-throw.

4.0 General Recommendations

The following are general recommendations designed to address the threats to programmatic and ecosystem function priorities in the Crum Woods listed in Section 2.

4.1 ROLE OF CRUM WOODS

The first step in implementing a conservation and stewardship plan for the Crum Woods is to establish their role, to give the Woods "standing" within the College community. There must be a foundation of respect among users, decision-makers, and others who come into contact with the site such that it is no longer perceived as the "back lot," but as a valued educational facility for the College community. While the surveys show that Crum Woods is appreciated by all members of the College community, no one has taken responsibility for its care. More critically, the College has not provided the significant resources required for proper stewardship. As a result, numerous basic stewardship tasks (elimination of hazards, trash cleanup, trail maintenance, monitoring boundaries) have been neglected for many years or decades. With the new and growing threats of overabundant deer, invasive vegetation, fragmentation and unwarranted use, there is a growing urgency to give the Woods the standing and attention they deserve before they are no longer able to provide the goods and services everyone has taken for granted. The institutional means need to be established to sanctify and protect the Woods' boundaries and resources against further loss and degradation. Without proper standing in the institutional framework of the College, irreversible but completely avoidable losses are inevitable.

4.2 LAND CONSERVATION PRIORITY

Different areas of land in the Crum Woods represent a wide spectrum of assets and capabilities. They vary in diversity of species and habitats, presence or absence of species with special significance for teaching or conservation, and degree of degradation by introduced invasive species or historic land use. Some are among the last refuges for important elements of declining native biodiversity in southeastern Pennsylvania. One of this plan's main purposes is to classify various parts of the Crum Woods according to their values and capacities for teaching, scientific research,

Community Garden Parcel

- **Size**: 1.7 acres

- **Description**: A combination of upland mowed turf and woodland with strong presence of introduced species. See Sections 1.2.1.3 and 1.2.2.2 for detailed descriptions of these forest communities. Located on the southeast corner of the intersection of Yale and Harvard Avenues. The parcel is detached from the main body of the Campus Woods by approximately 1,000 feet.

- **Management issues and recommendations**:

  Tree regeneration – Generally sparse due to deer browsing. Given the proximity of residential structures, it would be prohibitively difficult to implement any management of the deer population in this unit.

  Invasive plants – There is severe impact of invasives within the wooded section, including Norway maple, privet and Japanese honeysuckle. Given its low ecological value, it is recommended that any work within this unit be a low priority. See Appendix J for information on controlling invasive plants.

  Unwarranted use – The neighbor on the southeast border is discarding debris (yard waste, old lumber) within the unit. If the College intends to maintain long-term ownership of this parcel, it is recommended that the recently surveyed boundary be marked and periodically monitored. The neighbor should be notified of the encroachment and the debris should be removed.

  Hazards – There are residential structures and public roads close to the border of the unit and moderate activity in the community garden within it. It is recommended that this unit be part of an annual hazard-tree monitoring program.

  Appropriate ownership – To restore and manage this area properly will consume a significant amount of staff time — time that would be better spent on more environmentally and ecologically important areas of the Crum Woods. The College should assess the benefits of maintaining ownership of the parcel and consider using this parcel as an asset property and investigate the potential for sale to the neighbors or the township (to continue as a community garden), with the proceeds going to a Crum Woods Stewardship Endowment.

Wister's Garden

- **Size**: 2.0 acres

- **Description**: A combination of red oak-mixed hardwood forest, tuliptree-beech-maple forest, and forest with strong presence of introduced species. See Sections 1.2.1.1 and 1.2.1.3 for detailed descriptions of these forest communities.

sustaining significant remnants of the region's natural heritage, and maintaining the environmental quality of central Delaware County. Natural Area Cores, Natural Area Buffers, riparian forest buffers, wetlands, large contiguous forest blocks, functioning forest interior, native meadows and shrublands, rare species habitats, historic sites, and Arboretum gardens are among the key categories of land considered in prioritizing conservation efforts in the Woods (see Section 2.2.2 and Table 6). Section 5, Management Units, identifies these parts of the Crum Woods mosaic and, for each unit of land, discusses issues and opportunities and outlines specific restoration and management recommendations.

4.3 OVERSIGHT AND MANAGEMENT INFRASTRUCTURE

To maximize the role of the Crum Woods in fulfilling the College's stated mission, we recommend that the College dedicate additional resources to assure proper management and use of the area. The current level of resources devoted to the Woods is clearly inadequate to protect the site's educational, environmental and ecological values and to provide a consistently safe and enjoyable recreational environment. The College needs to incorporate the management of the Woods into its institutional framework and to provide funding both for coordinating use and for monitoring and addressing management issues in a timely manner. This commitment will not only promote better management of the Crum Woods, but will also engender a foundation of respect for this valuable resource.

4.3.1 Dedicate staff to Crum Woods management

The most important commitment for the College to make is to dedicate staff time to the management of the Crum Woods. Given the size and complexity of the Woods, current restoration needs, ongoing maintenance needs, and levels of legitimate and unwarranted use, it is strongly recommended that two positions be established within the College. The first is a full-time manager to coordinate, implement and monitor management activities and use within the Crum Woods The manager would need to possess: (1) an academic grounding in ecology or forest management, preferably at the master's level; (2) practical, hands-on experience in managing natural areas; and (3) the ability to communicate effectively with a wide variety of people. The manager would require periodic assistance from other College offices and departments, especially Scott Arboretum, for larger or specialized projects in the Woods. He or she could, in turn, assist Arboretum staff on projects. Regular use of volunteers will be a means for minimizing additional staff needs.

A second position, held by a member of the faculty, would directly supervise the manager. This person, along with representatives from appropriate offices (Facilities, Scott Arboretum), other faculty, staff and students would constitute a Crum Woods oversight committee, which would oversee the use and management of the Woods and

review proposals for new or modified uses. The faculty supervisor would receive relief from some teaching responsibilities in exchange for overseeing the management of the Woods and his or her department would receive resources to hire replacement courses. The position could be rotated among faculty with strong research interest in the woods. A system would be needed for appointing an acting faculty supervisor when the faculty supervisor is on leave. The faculty supervisor's responsibilities would include:

- acting as a strong advocate for the Crum Woods and for the manager with the faculty and administration
- mediating competing interests and working to build consensus among faculty and among high-level stakeholders in general
- helping to insure that the manager and the Crum Woods are provided with sufficient resources to fulfill their functions
- exercising authority to make certain decisions, if necessary, by arbitration or compromise, and decisions that the committee feels are not pressing enough to convene over or that need to be made sooner than committee members are available to convene

This committee/faculty supervisor/manager system is the standard at many other colleges and universities with significant natural land resources to manage.

Given that the College may not be in the position to make an immediate financial commitment to the manager position (although alumni surveys suggest that the College might be able to find support for the position among graduates; see Appendix A), the College could start by making permanent the appropriate committee and part-time faculty supervisor position. Together, they could address immediate issues and assist the administration in identifying funding sources for the manager position and needed restoration projects.

4.3.2 Oversight

Many problems arise in the Crum Woods in large part because there is no systematic monitoring of use. The manager should make routine rounds and maintain regular communication with others who have business on the property, for example, researchers, recreational users, public safety and police officers, Smedley Park managers, the local wildlife conservation officer, and those responsible for maintaining utility rights-of-way. Such oversight can prevent and resolve conflicts between and among outside users and members the College community. The manager would be the link to outside stakeholders and would be responsible for information exchange and for administering a permit system to control and monitor use.

In addition, it will be vital for the manager to seek and maintain a network of concerned stakeholders who can act as an extended set of eyes and ears. Examples include professors who teach in the Woods, the Crum Woods maintenance volunteer group, members of the citizens group Friends of Smedley Park, and student environmental and outdoor groups.

It is instructive to cite a few recent examples of problems that would likely have been averted with oversight by a manager:

- Philadelphia Suburban Water Company employs contractors for regular maintenance of its aqueduct rights-of-way, including the one that cuts through the old-growth forest in the Martin Forest Natural Area. In the course of maintenance work in 2001, several very large oak trees just beyond the margins of the area that has traditionally been cleared were cut down without consultation with any representative of the College. In response to complaints after the fact by members of the Friends of Smedley Park, an official of the Water Company stated that the unsupervised contractor had exceeded the bounds of his contract and authority in removing the old-growth trees (J. Auten, personal communication).

- The land leased to the Borough of Swarthmore and Nether Providence Township for the composting facility does not have its boundaries marked on the ground. The only representation of that boundary is a line on a detailed site plan attached to the lease, labeled as the "Limit of Disturbance," which encompasses about three acres (1.2 ha). However, in the decade or so since the facility opened, operations have spilled over into a somewhat larger area of perhaps four acres (1.6 ha), escalating the risk to the integrity of a nearby Natural Area Core, a natural heritage site of regional significance.

- Delaware County recently completed a plan for the construction of several new playing fields, an access road, a new bridge over Crum Creek, and a large parking area in Smedley Park. Construction drawings sited the proposed parking area, part of the access road, and one side of the proposed bridge on the College's Martin Forest tract, where, if built without College approval, they would be in clear violation of the lease. The College became aware of the plan only by happenstance, following a conversation between one of the authors of this conservation and stewardship plan and a member of the Friends of Smedley Park.

An important responsibility of the manager will be to monitor compliance with present and future leases, easements, and other agreements governing the use by others of Woods land. An example is the third clause of the Martin Forest tract lease, which spells out the stewardship obligations of Delaware County as lessee:

> *The Lessee shall keep the demised premises in good condition during the continuance of this lease and any renewal thereof; shall remove all rubbish, refuse matter and debris therefrom; shall*

supervise, maintain and police the same adequately and to the satisfaction of the Lessor; and at the termination of this lease deliver up the said premises to the Lessor in as good condition as the same now are, damage by accidental fire excepted. No trees or shrubs shall be cut without written approval by the Lessor. No roads, walls, fireplaces, buildings, bridges or signs over 18" x 2' in size, nor paths made of materials other than those now on the demised premises shall be constructed on the premises without the written approval of Lessor. The premises shall not be used for the storage of any material or articles whatsoever.

4.3.3 Establish a communication link to and between all stakeholders

4.3.3.1 Dissemination of information

Because the Crum Woods are a common connection for most of the College community (students, professors, staff, neighbors) it will be vital to keep all stakeholders continually informed and aware of activities and issues related to management and use of the Woods. Within the College community, regular dissemination of information about curricular and research uses would be of interest to the many stakeholders. Reprints of scientific publications and faculty reports of curricular use should be circulated at least annually to appropriate College personnel, such as the President, Provost, vice-presidents, deans, selected faculty, members of the Board of Managers, and Alumni Association officers.

4.3.3.2 Signage and publications

Proper signage is essential for controlling use of publicly accessible open space. Unless visitors are notified of the rules and regulations they will assume that anything not specifically prohibited is allowed. Clear signage at all trailheads is the most effective means of informing users.

An informational brochure is a good way to orient users to the site, to reinforce property rules and to explain the management goals so users may better understand listed prohibitions. Such a publication should include a trail map, information on curricular and research uses, natural history, and rules designed to minimize environmental damage and conflicts among uses, and it should be distributed to all students, faculty, and interested visitors.

The best signage and brochure design, however, will be wasted if the listed rules are not enforced. Until the position of manager can be established, it is recommended that at least some staff time be dedicated to monitoring and enforcing property rules. Given the high amount of use by Swarthmore residents, the College would be reasonable in requesting assistance from the borough police in monitoring and enforcement.

4.3.3.3 Review and permitting

To properly evaluate proposed new uses of the Woods, a review and permitting protocol needs to be established. The Crum Woods oversight committee would review proposals and issue permits if the new use does not have an adverse impact on current permitted activities. Coordination of this process would be the responsibility of the Crum Woods management staff.

4.3.4 Permanent source of funding

Enhancing the stewardship of the Crum Woods will naturally be an additional financial cost to the College. A significant increase of dedicated staff time (unavailable from existing departments and offices) will be required along with associated costs (training, equipment, materials). This should not be viewed as a perpetual burden to the budget, but as an investment in fulfilling the mission of the College. An example of good stewardship, an attraction to potential students, a viable outdoor classroom for existing students, and a venue for community interaction — all will be the long-term benefits of this investment. Funding should be sought for a Crum Woods Endowment to meet annual stewardship needs. Potential sources of contributions to this fund are alumni, philanthropic foundations, wetlands mitigation projects, and the sale of a conservation easement on at least the Natural Area Cores of the Crum Woods (see Appendix H).

4.3.5 Elimination of unnecessary holdings

In addition to creating a permanent funding source for the stewardship of the Crum Woods, it is also recommended that the College divest itself of property that is a potential drain on financial resources and has little benefit to the College's mission. Moving questionable assets to a more appropriate owner would add income to a stewardship endowment, remove the burden of ownership (taxes, insurance, maintenance), and free up resources to dedicate to more valuable-to-mission lands. There are two parcels included in this study that the College should consider eliminating from its portfolio.

- **Baltimore Pike Parcel** – This parcel at the northern tip of the Campus Woods is over a quarter-mile from the main body of the Woods. Surrounded by development, it provides negligible benefit to the College community or the Campus Woods. The College should consider a sale to Springfield Township, neighbors or another private party with appropriate restrictions to protect the residential community and the intermittent stream that flows through the parcel.

- **Community Gardens Parcel** – Located at the southern end of the Campus Woods, this parcel is also disconnected from the Woods. The Borough of Swarthmore might more appropriately own the parcel, with perhaps some

portions sold (with restrictions) to neighbors to buffer their properties and to augment a stewardship endowment.

4.4 VEGETATION MANAGEMENT AND RESTORATION

4.4.1 Reduce forest fragmentation and "edge effect"

4.4.1.1 Adopt a "no net loss" policy on the total area of unfragmented forest

The total area of contiguous forest at the present site of the Crum Woods has been fluctuating since the mid-seventeenth century, when it was part of a vast forest block. The nearest breaks in continuous tree cover most likely were the gardens around small Native American villages several miles distant. By the time the first aerial photographs were taken in 1937, the contiguous forest remaining between the two roads that cross Crum Creek and abut College land (Plush Mill Road-Wallingford Road and Yale Avenue-Rose Valley Road) had been reduced to 207 acres (84 ha). Nearly a third has been lost since then in a steady decline to its present size, 146 acres (59 ha). Of this forest block, 88% is in the College-owned Campus Woods and the remainder is in private ownership.

A "no net loss" policy would mean that any additional reductions in the area of contiguous forest that are deemed necessary in the future should be balanced by forest restoration on College-owned open land immediately adjoining another part of the Crum Woods. Any such mitigation attempt, at minimum, would need to fulfill two criteria:

- The total area of the two Crum Woods forest blocks (the Campus Woods and Martin Forest) must remain the same or increase.

- The total area of forest interior in the Crum Woods (defined as the area more than 100 m [305 ft.] from an edge) must remain the same or increase.

4.4.1.2 Decrease the edge-to-area ratio and increase the area of functional forest interior

These objectives can be accomplished by reforesting selected "peninsulas" and "islands" of non-forested land that presently intrude into the main body of the contiguous forest. The restoration of forested riparian buffers along the edges of the Crum Meadow and the lawn in front of Strath Haven Condominiums will have a minor but significant positive effect, as will reforesting part of the Natural Area Buffer at the north end of the Southern Red Oak Natural Area. More substantial gains will result if reforestation is undertaken on portions of the land currently in grass cover or under

debris piles on the Swarthmore Farm Plateau and downslope from the buildings at Crumwald Farm (Clarke House, barn and nearby faculty house).

4.4.1.3 Reduce deleterious edge effects

Edge effects are conditions in and near the forest-nonforest transition zone that weaken or kill native plants, foster the growth of invasive plants, provide access for nest predators (e.g., raccoon) and parasites (e.g., brown-headed cowbird), and repel forest-interior animal species. Dense, healthy mid-canopy and shrub layers at the forest edge minimize edge effects (Yahner 1988; Cadenasso et al. 1997, 2002; Pickett et al. 1999, 2001; Cadenasso and Pickett 2000, 2001). A forest edge that has existed for many decades often already has a well-developed wall of leaves and branches extending from near the ground to the upper leaf canopy. Remediation is required at more recent edges, where trees have been cut down within 20 years, and at edges where landscape maintenance practices restrict new growth. Such edges are said to have high permeability. Native trees and shrubs of species appropriate to specific site conditions should be planted along forest edges with high permeability. Mixtures of evergreen and deciduous species should be used where the natural community would include evergreens, in order to enhance impermeability in all seasons. Construction and maintenance practices should be avoided that would damage understory and mid-canopy vegetation at the forest edge and increase its permeability to sunlight, air movement, and the influx of seeds.

4.4.1.4 Promote protection and management of adjacent forested parcels

Most of the land around the College has been developed but there are still forested areas of significant size adjacent to College lands, particularly the Martin Forest. At the north end of the Campus Woods, between College land and Baltimore Pike, is a forested tract owned by Barrow Partnership. At the south end, downstream along Crum Creek, is Nether Providence Township's Leiper Park. Martin Forest is surrounded by forested parts of Smedley Park, the Springfield Township Country Club, and Springfield Township's Jane Lownes Park. The ecological and environmental goods and services of the Woods are enhanced by the presence of these forested areas, which buffer the Woods from edge effects and create a larger unfragmented forest. Ideally, coordinated management of this forested landscape would provide the greatest environmental and ecological benefits.

The College, perhaps with the assistance and support of a local land trust, conservation planning professional, or watershed group, is in a position to initiate a discussion with key adjoining landowners about the importance of protecting the remaining forest. The manager could coordinate with adjoining landowners to most effectively address shared management issues (e.g., overabundant deer, invasives, unwarranted use).

4.4.2 Target invasive species that pose the greatest threats to ecosystem integrity and native species diversity

Only a small minority of introduced species have proven to be invasive in our region, but their destructive impact on native biodiversity is surpassed only by habitat destruction and fragmentation. Some of the worst offenders in our region are rampant in parts of the Crum Woods (Appendix J). An invasive species is one that rapidly spreads and outcompetes multiple native species, in all likelihood chiefly because of the absence of the predators, pathogens and herbivores that keep it in check in its place of origin. **Invasive plants that are compromising the integrity of the Crum Woods' Natural Areas should receive the highest priority for control efforts.** Specific methods have been developed by Natural Lands Trust, The Nature Conservancy, the National Park Service, and other organizations and agencies in the business of natural area stewardship for controlling each species without causing lasting harm to the native flora (Section 5; Appendix J).

Removing invasive plants is an essential step in restoring degraded ecosystems, but the removal process itself, if not done properly, can be catastrophic to the health of a forest or wetland and its wildlife. Removing trees such as Norway maple and groundcovers such as English ivy opens up the canopy and scarifies the soil, conditions that are ideal for the rapid establishment from seed of opportunistic species, a category that includes most invasives. Removing understory shrubs such as bush honeysuckles, privet or sapphire-berry can transform a forest stand that was a haven for migratory and resident birds and other animals to one devoid of understory cover and thus no longer a viable refuge (from predators), feeding or breeding habitat for many species. Removal without replacement has numerous subtle effects but some effects can be dramatic, such as a striking decline in birds that were once common. For example, house wrens and song sparrows no longer inhabit particular riparian sites where Japanese knotweed was recently removed; other species are less common in understory now devoid of once-thick invasives such as oriental bittersweet (Kight 2003; J. Williams, personal communication). Of the birds in the Crum Woods that exhibited declining trends over a 7-year period, 80% belonged to ground-foraging species that require dense, low plant cover such as eastern towhee, slate-colored junco and Swainson's thrush (Kight 2003). Similarly, a decline in red-tailed hawks (Kight 2003) could also reflect a loss of habitat for the small mammals they use as prey, which also require dense, low plant cover. **Invasive plants should be removed in patches, affecting no more in one year than about 10% of the contiguous area of any one plant community occurrence** (i.e., each polygon on the Plant Communities maps, Figures 4 and 5).

To keep the "cure" from being worse than the "disease," replacement planting must be undertaken in the same year as removal. This will provide the native species with an edge in recapturing the growing space made available by weeding out invasive species. Any site where plants to be removed comprise more than 25% of the cover within their forest layer (canopy, subcanopy, shrub, herbaceous) will need to be replanted. Removal

should be undertaken at times of year when direct disturbance of wildlife would be minimal, preferably late fall or winter (Kight 2003). Replacement plantings should precede the onset of the spring breeding season because many birds return to the same sites year after year to reestablish territories and renest. To insure their survival and to maintain ecosystem integrity, replacement plants must be of native tree, shrub or woody vine species carefully selected to be appropriate to soil conditions and the community type at each individual restoration site within the Crum Woods. Many of the species typical of each indigenous plant community in the Crum Woods are listed in Section 1.2. A comprehensive list of native woody species suggested for planting is given in Appendix M. Further information needed to match species to community types is presented in Fike (1999), Rhoads and Klein (1993), and Rhoads and Block (2000).

Replanting after removing invasive plants accomplishes several objectives. It replaces vertical forest structure and bird cover where they had been provided mainly by the invasive species (e.g., where bush honeysuckles, privet or sapphire-berry are removed). Where invasive species have eliminated entire forest layers (e.g., Norway maple and English ivy, which eradicate native shrub and herbaceous layers in forests), replanting after removal restores long-lost vertical forest structure and bird cover. Where invasive plants are removed from streambanks or floodplains (especially Japanese knotweed) or from steep slopes, replanting renews protection against soil erosion. In all cases, the planted native species restore lost components of the indigenous food web; invasive species' leaves and stems are little utilized as food by native wildlife, which is one of the reasons they succeed so well here.

It must be emphasized, however, that planting should be viewed as only one component of forest restoration where invasive species are removed. The goal of maintaining the entire Crum Woods as a set of natural communities dominated by native species will be met only by reducing the deer population to a level that allows natural regeneration from seed produced by native species already growing in the Woods. Once natural regeneration is restored, a healthy crop of seedlings and saplings of native species will be poised to assume the growing space vacated by the natural decline and mortality of native species or the deliberate removal of invasive species. If the deer population were not addressed, perpetual reliance on planting would be a severe drain on staff and financial resources and would require permanent, extensive use of unsightly measures (fencing, tree shelters) to protect plantings from deer browsing. For this reason, a deer management program should be established before widespread removal of invasives.

4.4.3 Treat dead wood as a valuable resource

Although often viewed as unsightly waste material, dead wood is the foundation of the forest food chain and also provides shelter to many animal species. In addition, fallen logs and limbs serve as a water reservoir in times of drought. They soak up water and can retain it for long periods of time, providing nursery sites for seedlings, especially

during dry spells. Small animals like salamanders depend on large logs for needed moisture. Logs help control erosion by inhibiting surface water flow and by absorbing water in place. Mycorrhizal filaments reach up into fallen wood from tree roots to extract valuable nutrients. Individual dead trees — "snags" — are also important to leave, when they do not pose a hazard to humans or structures, because they are used as dens by many animal species and harbor insects and microorganisms that provide food for many birds and small mammals. These, in turn, are food for larger mammals and birds of prey.

Dead wood should be viewed as a valuable resource within the Crum Woods. It should receive as little "processing" as possible. Hazard trees should, of course, be dropped to prevent injury to trail users, neighbors, or structures. Any tree downed by nature or chainsaw, however, should be left on the ground in as few pieces as needed to eliminate any trail obstruction, future hazard, or attractive nuisance. Care needs to be taken to avoid covering areas of special value such as dense stands of spring ephemeral wildflowers.

4.5 WILDLIFE MANAGEMENT

In general, maintaining healthy plant communities will foster a diversity of wildlife populations. Addressing the existing conservation threats will, therefore, be the primary wildlife management activity. Major wildlife management needs include restoring damaged wetlands, removing introduced invasive plant species from Natural Area Cores and Buffers, replanting native trees and shrubs immediately following invasive removal, converting some of the large expanses of mowed turf to native meadows, converting streamside mowed turf to forested riparian buffer, and restoring forest habitat in cleared areas within Natural Area Buffers. The most pervasive, large-scale wildlife management issue in the Crum Woods, however, is the need to maintain healthy, sustainable plant communities by controlling overabundant populations of white-tailed deer. Deer are problematic in this region due to the demise of natural predators and the mismanagement of the species by the Pennsylvania Game Commission over the last few decades. Control of deer in urbanized areas is further complicated by the fact that lethal removal is the most effective, and the most practical, means of population control.

The deer population in the Crum Woods is not at levels seen in other parts of the region, but there is clear evidence (the near absence of advance tree regeneration, a clear browse line in several areas) that deer are impacting the long-term health of the forest. In theory, forests in our region can support approximately 5 to 10 deer per sq. mi. (2 to4 km^{-2}) before forest biodiversity is compromised (deCalesta and Stout 1997). With a total of 146 acres (0.23 sq. mi. [0.58 km^2]) including contiguous non-College-owned forestland, the Campus Woods could support about two deer without undue damage. It is not uncommon to see groups of six or more deer in the Campus Woods and

neighbors have reported larger groups in their backyards adjoining the Woods. A population survey to estimate the current deer density in the Crum Woods would be an important first step in addressing this issue. Following this, a contingency plan to mimic the population-stabilizing effects of natural predators on white-tailed deer should be developed to eliminate this threat to forest health (Section 5, Appendix I). And finally, a permanent, quantitative monitoring program to assay the extent of the deer population's effect on biodiversity and ecosystem function should be established as part of an effective management strategy (Section 6). As part of this program, it would be helpful to erect exclosures in strategic locations to visually demonstrate to Crum Woods users the effects of deer overabundance and the need for control methods. Such exclosures are also amenable to quantitative ecological analysis and thus have strong curricular value.

Wetlands are disproportionately important habitats for birds (see Section 2.2.2.5) as well as frogs, toads, salamanders, turtles, dragonflies and many wetland-specialist members of other groups including charismatic organisms such as mammals, butterflies and native orchids. The two best remaining wetlands in the Crum Woods, Skunk-cabbage Hollow and Oxbow Swamp (both designated as Natural Areas), have been degraded by past dumping of construction debris and invasion by phragmites. Funding opportunities are increasingly available for wetland restoration, for example, through the Pennsylvania Department of Environmental Protection's Growing Greener Program and wetland mitigation grants.

Removal of invasives (see Section 4.4.2) is a wildlife management issue, because invasive plants are generally poor-quality sources of food for native wildlife and the native plants that should increase after removal are for the most part higher-quality sources. Replanting appropriate native species when removing invasives is also crucial to the maintenance of wildlife habitat, by sustaining vertical forest structure and bird cover and restoring diminished or lost components of the indigenous food web. Shrub-layer density and plant species diversity have strong positive correlations with wildlife habitat value, particularly for birds and mammals.

Approximately 25 acres (10 ha) of the Crum Woods are classified as mowed turf, equivalent in area to between 25 and 30 football fields. Maintained with costly, frequent management using fossil-fuel-powered machinery and sometimes chemical herbicides, the wildlife habitat value of turf is essentially nil. At present this land's ability to contribute ecosystem services is severely impaired. If restored to native meadows or reforested, it would begin functioning once again as wildlife habitat, as well as having increased value for aquifer recharge, flood control, sediment retention, erosion control, soil development, nutrient assimilation, local climate regulation, and opportunities for education, research and nature appreciation. In general, turf next to Natural Area Cores or within 75 feet (23 m) of stream margins should be reforested and other turf areas in the Crum Woods may be converted to native meadows.

Forested riparian buffers, among many other benefits (see Section 2.2.2.3), provide food, shade and migratory corridors for wildlife. Reforesting open areas adjacent to Natural Area Cores curtails the "edge effects" of increased wind, light and heat, decreased humidity, and dissemination of seeds of invasive introduced species into the forest while expanding the habitat available to forest-dwelling wildlife. Tall, dense stands of native meadow grasses and wildflowers provide rich habitat for many species of birds, mammals, butterflies and other native animal life. Meadows dominated by native plant species are scarce in the region and therefore add significantly to community diversity. Furthermore, they accommodate a group of animal species that is in decline and includes several rare species.

Moreover, it should be noted that wetland restoration, meadow creation and maintenance, reforestation, and riparian buffer projects include a variety of education, research and volunteer service opportunities for faculty, students and other members of the College community.

4.6 STORMWATER MANAGEMENT

The overall goals for addressing stormwater management in the Crum Creek watershed are to:

- Protect and enhance stream water quality throughout the Crum Creek watershed by maintaining and restoring the natural capacity of Crum Woods and adjoining lands to **filter and remove pollutants from stormwater runoff**.

- Reduce the impact of flooding and sustain stream baseflows in the Crum Creek watershed by maintaining and restoring the natural capacity of Crum Woods and adjoining lands to **maximize the recharge of groundwater**.

Specific objectives that could be implemented within College lands include:

- **Improving the quality of runoff** draining into the Crum Woods by minimizing sediment and other pollutants contained in runoff from adjoining impervious surfaces and lawns, and by eliminating on-site erosion problems. Needs include trail management, restoration of gullies, filtration of parking lot runoff, and the continued reduction of lawn chemicals, which was begun some 10 years ago.

- **Maximizing recharge of groundwater** in and around the Crum Woods by directing sheet flow runoff from parking lots, lawns, and rooftops into the ground as much as possible.

- **Auditing the stormwater management ordinances** for the borough of Swarthmore and Nether Providence Township to determine whether these

recommendations can be met by following existing code. If not, a model ordinance should be provided to the municipalities for consideration, in anticipation of an updated ordinance that will be required under a pending Crum Creek watershed-wide Act 167 stormwater management plan (being prepared by the Delaware County Planning Commission) and pending U.S. Environmental Protection Agency National Pollution Discharge Elimination System Phase II requirements. These recommendations are consistent with the findings of the Crum Creek watershed and source water assessment project, co-sponsored by the Philadelphia Suburban Water Company, Delaware County Conservation District, and Chester-Ridley-Crum Watersheds Association (Schnabel Engineering 2001).

- **Promoting water quality and quantity best management practices (BMPs)**, and model ordinances that permit them, as models for the community.

- **Establishing a campus-wide awareness and education program** for non-point-source pollution impacts. This type of program should be modeled after those used in the Chesapeake Bay Program (Chesapeake Information Management System 2001), stressing actions such as reduction of lawn chemicals, promotion of natural landscaping, and stenciling of storm drains ("Do not dump. Drains directly to creek.") on campus.

Identifying and addressing existing stormwater management problem areas (e.g., poorly designed basins, gully erosion problems, paved surfaces draining directly to the Woods, flooding problems) through incorporation of recommended stormwater "retrofits" can greatly improve the quality and quantity of water in streams, wetlands and aquifers. The following best management practices can be used to carry out objectives 1 and 2 above, either by retrofitting existing improvements or as part of the design of new improvements:

- Infiltration trenches/sand filters
- Infiltration basins
- Shallow wetland/pocket wetland systems
- Bioretention swales/berms

- Rain gardens
- Rooftop gardens

4.7 RIPARIAN AREAS

The ideal riparian buffer recommended by the U.S. Forest Service is a 95-ft. (30-m) strip along each side of a stream or water body consisting of three zones. The first zone is a 15-ft. (5-m) strip next to the stream or water body of an undisturbed forest that provides detritus and helps maintain lower water temperatures vital to fish. The second zone is a

60-ft. (18-m) strip of managed forest where filtration, deposition, plant uptake, anaerobic denitrification and other natural processes remove sediment and nutrients from runoff and subsurface flows. The third zone is a 20-ft. (6-m) grass or grass and shrub strip providing runoff control where concentrated flows are converted to dispersed flows by water bars or spreaders, facilitating ground contact and infiltration. Narrower forest and shrub buffers, as well as properly designed grass buffers, also provide degrees of benefit.

There are good riparian buffers along most of the Crum Creek as it travels through College property. The exceptions are the Crum Meadow and the open area in front of the Strath Haven Condominiums at the southern end of campus. Efforts have been made to establish a riparian buffer at the Meadow. The first tree and shrub plantings were, unfortunately, followed by destructive flooding from hurricane Floyd, but more recent plantings have held up well to date.

4.8 TRAILS

The trail system needs to be reviewed and modified with the goals of minimizing the number of trails (to limit maintenance needs, erosion potential, and soil compaction) and addressing current erosion and safety problems. In general, this will entail closing redundant trails, rerouting trails, and installing appropriate water control structures in unavoidable problem areas (Section 5; Appendix K). Unwarranted, *ad hoc* creation of new trails or inappropriate use of trails should be addressed through education (signage, Crum Woods informational brochure, meetings with user groups) and enforcement. These tools will be effective only if sufficient staff time is dedicated to the management of the Crum Woods.

4.9 AESTHETICS AND HAZARDS

Under the stewardship of the College, there have been many different uses of the Crum Woods. Some of these uses have left visual scars (debris piles) that impact the aesthetics of the Woods; some have created hazards (old structures) to current human users and wildlife that are liability concerns for the College. In addition, recreational users and neighbors have viewed the property as a convenient location to deposit party trash and yard waste. The refuse from these uses reflects poorly on the stewardship of the property and projects a tacit approval of these activities.

A commitment to stewardship includes the removal of residual trash, debris, and hazards. Removal of debris piles in and adjacent to forested areas should be followed by restoration of these areas to native vegetation. Future storage or deposition of construction materials and debris should be prohibited in forested areas and a 50-ft. (15-m) wide buffer zone created on the non-forested side of the forest edge. Property

boundaries need to be monitored on a regular basis to curtail dumping of lawn and garden waste by neighboring residents.

In addition to the removal of old structures to eliminate hazards, regular attention should be given to the monitoring and removal of hazard trees in the Woods. The level of scrutiny should be driven by the amount of human use and the presence of structures that could sustain damage in or adjacent to each area of the Woods. The monitoring program should focus on high use areas or areas with significant structures. Snags (dead, standing trees) in areas that are infrequently used are best retained for their wildlife benefits.

4.10 SWARTHMORE FARM PLATEAU

There is a proposal to use part of the Swarthmore Farm Plateau, which includes the Crum Woods' largest piece of gently sloping land at about 15 acres (6 ha), as a site for one or more new athletic fields. The intent is to replace the rugby field, displaced in 2001 by the construction of a new parking lot, and possibly to replace a field that may be lost with the siting of a proposed hotel on college property. This proposal has been coupled with the idea of building an approximately 8-foot (2.4-m)-wide bridge across Crum Creek to provide direct access between the proposed fields and the Lamb-Miller Field House. This bridge would be primarily for pedestrians, but it would also be able to accommodate light utility vehicles such as a Daihatsu Hijet or a Toro Groundsmaster lawnmower. There are several issues pertinent to Crum Woods conservation and stewardship that must be considered as the potential benefits and costs of these proposals are weighed.

4.10.1 Southern Red Oak Forest Natural Area

A little over half of the Plateau area is occupied by portions of three Natural Areas (Figure 4), mainly the Southern Red Oak Forest Natural Area. The Core of this Natural Area, which lies entirely on the Plateau and its perimeter slopes, is the most pristine forest stand remaining in the Campus Woods. An outstanding example of two native communities, dry oak-heath forest and dry oak-mixed hardwood forest, it also has an exceptionally high diversity of native tree and shrub species. It is the habitat for a recently discovered population of a rare tree species, southern red oak (*Quercus falcata*), the only state-listed rare plant species confirmed as still surviving in the Crum Woods. This stand is at the extreme northern limit of the species' range. It is most likely a remnant of a much larger aboriginal population of the species. The trunk of the largest individual, which is probably quite old, measures 31 inches (78 cm) in diameter. The Natural Area Core of 7.3 acres (3.0 ha) is unique in the Campus Woods in its virtually complete lack of invasive plant species. In southeastern Pennsylvania this is a rare phenomenon indeed. Protecting this Natural Area and preventing its degradation by invasive species, edge effects, and other adverse influences is one of the highest

stewardship priorities in the Crum Woods. Section 5 presents detailed recommendations on how this may be accomplished.

4.10.2 Composting facility

The composting facility (see Section 1.4.2.1) lies almost entirely within the Buffer portion of the Southern Red Oak Natural Area. The open ground along the composting facility's perimeter and the adjoining forest edge are used as a dumping ground for stone, concrete waste, discarded metal scrap, and the wood generated by the removal of hazardous or diseased trees from throughout the Arboretum. An area of about one acre (0.4 ha) between the paved surface of the composting facility and the Natural Area Core is maintained in turfgrass by frequent mowing. The grassy area functions partly as a catchment basin for contaminated runoff from the compost, but its openness creates severe edge effects in the forested Natural Area and invites dumping, littering and the temporary storage of heavy machinery used in the composting operation. The lack of trees reduces the effective size of the adjacent forest by allowing the "edge effects" of increased wind, light and heat, decreased humidity, and dissemination of seeds of invasive introduced species to pervade perhaps 20 percent of the forest's total area.

The composting facility was created with the best of intentions as a contribution by the College to the environmental well being of the community, beyond the many benefits enjoyed by local residents from the presence of the Crum Woods itself. However, it was apparently unknown to those who selected the site that they were placing essentially an industrial operation in the midst of one of the most outstanding natural areas in central Delaware County. Suitable sites for composting operations are far more common in suburban Philadelphia than intact, sustainable "monuments" of our natural heritage such as the Southern Red Oak Natural Area, whose value is beyond measure. We recommend moving the composting facility and the adjoining dumps to more suitable locations as soon as possible. In the meantime, it would be beneficial to move machinery and material storage from the south and west sides of the paved composting platform to the north side, erect a barrier along the south and west sides to prevent further incursions, and begin reforesting the area between the platform and the Natural Area Core.

4.10.3 Scenarios for the remainder of the Swarthmore Farm Plateau

A vital consideration in the decision-making process is the likely effects of various potential uses of the Plateau on the Crum Woods' overall integrity and ability to continue delivering high-quality benefits to the College and the broader community. Five alternative scenarios are envisioned here, three involving the development of one or more athletic fields and two without fields. Four presuppose that the composting facility will be moved to a different location.

4.10.3.1 Building athletic fields on the Swarthmore Farm Plateau

Any scenario in which one or more athletic fields, access road, parking lot, and attendant facilities are placed on the Plateau would increase at least two major sources of stress on the Woods west of Crum Creek, namely fragmentation and increased use. The degree of fragmentation would depend on how many fields were built and where, in relation to existing forests and open areas (existing conditions are shown in detail in Figure 10). The increase in use would stem mainly from the proposed bridge, independently of the number and siting of playing fields.

- **Fragmentation of contiguous forest and functional forest interior** — The total area of contiguous forest in the Campus Woods is 136 acres (55.0 ha); this is 93% of the total contiguous block, which also encompasses 10 acres (4 ha) of adjacent, non-College land. The College part of the contiguous block includes about 4 of the approximately 7 acres (1.6 of 2.8 ha) on top of the Swarthmore Farm Plateau that lie outside Natural Area boundaries and thus might be regarded as potentially developable land. If most of it were developed for playing fields, an access road, and a parking lot, the result would be the further fragmentation of the entire contiguous forest block to an area 5% smaller than it would be in a Plateau conservation and restoration scenario. The effect on the total area of functional forest interior would be similar in magnitude. This represents a highly significant loss in a forest block that has already been heavily fragmented.

- **Increase in use of the historically less accessible side of Crum Creek** — One of the main reasons that the three Natural Areas on the west side of Crum Creek are as intact as they are is presumably the area's isolation and relative inaccessibility. Unlike the east side of the creek adjacent to campus, the west side lacks significant trail erosion, has areas that are nearly free of invasive species, and is relatively free of littering, dog-walking, trail-biking and other activities that can be destructive to a site's natural qualities. Building a new access road, parking lot, and especially a pedestrian bridge across Crum Creek would inevitably bring much more intensive human use to the Woods on the west side.

Three development scenarios are considered. They differ in the amount of existing forestland to be lost, area targeted for reforestation, and loss or gain in functional forest interior (compare with existing conditions, Figure 10).

- Build-out Plan (Figure 11): Three playing fields, access road, parking lot, bridge and walkway (would decrease Plateau-area forest interior by about 62%).

- Modified Plan I (Figure 12): Two playing fields, access road, reduced parking, bridge and walkway, removal and reforestation of composting facility (would increase Plateau-area forest interior approximately nine-fold).

- Modified Plan II (Figure 13): One playing field, access road, reduced parking, bridge and walkway, removal and reforestation of composting facility (would increase Plateau-area forest interior to approximately 13 times its present size).

4.10.3.2 Conservation of the Swarthmore Farm Plateau

The values of the Crum Woods for teaching, research, the contemplation and appreciation of nature, and maintaining ecosystem function would be significantly enhanced by managing the entire Swarthmore Farm Plateau to conserve biodiversity. Two conservation scenarios are considered. They differ slightly in the area targeted for reforestation and the resulting gain in functional forest interior.

- Reforestation Plan I (Figure 14): Maintain or restore native plant communities and wildlife habitat on entire top of Plateau (would increase Plateau-area forest interior to approximately 23 times its present size).

- Reforestation Plan II (Figure 15): Maintain or restore native plant communities and wildlife habitat on entire top of Plateau, vacate Old Mill House and restore native vegetation between south end of Plateau and Avondale Road (would increase Plateau-area forest interior to approximately 23.5 times its present size).

4.11 TASK PRIORITIZATION

Given the reality that there is not enough money and time to implement all the above recommendations in the short term, the recommended tasks must be prioritized. Table 7's three columns contain the same tasks but in a different order based on different prioritization criteria. The first column ranks the tasks purely by the goal of properly managing the Crum Woods, the second, by the cost to implement each task, and the third, by a compromise between cost and management objectives, i.e., by the potential to provide the greatest benefit with the least financial pain.

Table 7. Major priorities for conservation and stewardship of the Crum Woods.

In approximate descending order of urgency and time-sensitivity	In approximate ascending order of cost to implement	Compromise order of urgency, assuming initially tight funding constraints
• Eliminate hazards	• Establish outstanding Natural Areas designations	• Eliminate hazards
• Establish outstanding Natural Areas designations	• Establish review and permitting protocol for use	• Establish outstanding Natural Areas designations
• Dedicate staff to management	• Establish communications links	• Dedicate staff to management
• Establish communications links	• Eliminate composting facility (assuming asphalt removal is carried out by borough and township)	• Establish communications links
• Maintain deer population at acceptable level	• Maintain deer population at acceptable level	• Establish review and permitting protocol for use
• Control invasive plants	• Eliminate/reroute/improve trails	• Eliminate composting facility (assuming asphalt removal is carried out by borough and township)
• Eliminate composting facility	• Expand riparian buffers	• Maintain deer population at acceptable level
• Establish review and permitting protocol for use	• Dedicate staff to management	• Control invasive plants
• Establish position of manager	• Control invasive plants	• Control stormwater inputs from campus
• Afforest composting site and fields behind Clarke House to the forest edge	• Control stormwater inputs from campus	• Eliminate/reroute/improve trails
• Expand riparian buffers	• Eliminate hazards	• Expand riparian buffers
• Control stormwater inputs from campus	• Afforest composting site and fields behind Clarke House to the forest edge	• Afforest composting site and fields behind Clarke House to the forest edge
• Eliminate/reroute/improve trails	• Establish position of manager	• Establish position of manager
• Establish a permanent funding source for management	• Establish a permanent funding source for management	• Establish a permanent funding source for management

5.0 Management Units

Section 4 highlighted the major stewardship issues concerning the Crum Woods as a whole and provided general recommendations for addressing these issues. This section divides the Woods into management units based on land use, conservation priority, resources, surrounding influences, and existing and potential threats (see Figures 16 and 17). Each management unit is described according to dominant plant communities and location, and the current management issues within each unit are cataloged. Restoration and management recommendations are presented, with more detailed information pertinent to each recommendation provided in appendices. The accompanying Management Issues Maps, Figures 18 and 19, show the location of specific problem spots (trail erosion, dumps, hazards) noted within each unit. Recommendations are summarized and prioritized in Table 8 at the end of this section.

5.1 UPLAND FORESTS

5.1.1 Core Upland Natural Areas

Wister Forest

- **Size**: 26.9 acres

- **Description**: Located on the northwest-facing mid- and lower slopes on the east side of the gorge, north of the railroad trestle. Predominantly a hemlock (white pine)-red oak-mixed hardwood forest. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing and a dense overstory; satisfactory in gaps at present. Deer pressure is likely low in this area due to a high level of human use, but there are initial signs (high proportion of spicebush, browse on blackgum rootsprouts) of increasing deer impact. To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations. Given

the high use of this area and its close proximity to campus, it would be a good location for one or more small deer exclosures to demonstrate and quantify the level of deer impact on forest vegetation.

Invasive plants – Generally low impact, although there are several problem species with established populations including English ivy, goutweed, Japanese honeysuckle and oriental bittersweet. Initial focus should be on the removal of the scattered individuals of invasive trees (Norway maple, corktree) and shrubs (privet, Japanese angelica-tree) to provide more sunlight for native tree regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present in the unit.) It is recommended that invasives be monitored annually and managed as needed. See Appendix J for information on controlling invasive plants.

Trails – Generally in fair to good condition; a higher level of maintenance is needed for the current level of use (see Appendix K for trail maintenance guidelines). There are several areas that require new and additional waterbars and a few sections that should be rerouted to retire highly eroded trail areas. Mountain bikers are creating outlaw trails in a few locations that disturb understory vegetation and soil on steep slopes. It is recommended, as part of the general review of the trail system, that permanent trails be established (the current number appears to be appropriate) and marked to minimize the creation of multiple trails and the associated disturbance to the forest.

Hazards – The deteriorated metal culvert located where the Creek trail crosses the small tributary of Crum Creek (H1) is a potential hazard to trail users. It is recommended that this be removed and the crossing filled with native stone. The stone steps that lead from Alligator Rock to Crum Creek (H2) are loose in many locations. It is recommended that they be reset or that this section of trail be eliminated.

Trash – There is a small amount of trash (bottles, plastic) scattered within the unit. A periodic cleanup by volunteers is recommended. In addition, there is a section of old irrigation pipe along the trail north of the railroad trestle that should be removed.

Hogback Knoll

- **Size**: 2.1 acre

- **Description**: Dry oak-mixed hardwood forest on the west side of Crum Creek, under and north of the railroad trestle. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – This is the only undisturbed area in Crum Woods with good native tree regeneration, in both seedling and sapling size categories. It is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]) to prevent degradation of this ecologically valuable area. See Appendix I for information on controlling deer populations.

  Invasive plants – Currently there is a very low impact of invasives, although several species, including grape, oriental bittersweet, English ivy and winged euonymus are beginning to move in from the edge of the unit. Given its ecological value, the area deserves close monitoring and quick action to prevent intrusion by invasive species. Priority should be given to cutting invasive vines overtopping the foliage of canopy trees on the southern edge of the unit. Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should be cut only when it starts to overtop the foliage of canopy trees. See Appendix J for information on controlling invasive plants. There are also several excavated soil pits on the west side of the unit that are potential establishment sites for invasive species. Unless there is some educational use for the soil pits it is recommended that they be filled and covered with organic litter from the surrounding area.

  Trails – Currently, a trail runs along the creek on the east side of this unit. To prevent degradation of its relatively pristine condition, it is recommended that any new trails should avoid this area.

  Trash – There is a small amount of trash (metal, bottles, plastic) scattered within the unit. A periodic cleanup by volunteers is recommended.

Trillium Slope

- **Size**: 2.7 acres

- **Description**: Tuliptree-beech-maple forest on the lower slopes on the west side of the gorge, south of the railroad trestle. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Generally sparse due to deer browsing and a dense overstory (subcanopy of Norway maple and American beech); barely adequate in gaps (mostly Norway and sugar maple) at present. There are signs of high deer pressure (high proportion of spicebush in shrub layer, numerous trails). To protect and enhance existing regeneration it is recommended that the College

monitor and control the local deer population to an appropriate 5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

Invasive plants – Light to intermediate impact by Norway maple and winged euonymus on lower slopes; severe impact on the upper slopes from privet, English ivy, Amur honeysuckle and Norway maple. It is recommended that invasives be monitored annually and managed as needed. See Appendix J for information on controlling invasive plants. Initial focus should be on the removal of the invasive trees (Norway maple) and shrubs (privet, Amur honeysuckle) to provide more sunlight for native regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present.) Care should be taken in removing the invasive trees and shrubs to avoid disturbing the trilliums during the growing season and to do this work in phases in order to monitor the effects of increased light on the trilliums and the nearby invasives. A dormant-season spraying of the evergreen invasive groundcovers should also be considered.

Trails – Trails in this area are informal paths and deer trails that receive low to moderate use and little or no maintenance. There is an excessive number of trails and some sections are poorly located, for example, running along very steep slopes or directly down a steep slope. It is recommended that permanent trails be established (the number of trails should be reduced), marked, and maintained regularly to minimize the haphazard creation of new trails and the associated disturbance to the forest. See Appendix K for trail maintenance guidelines.

Trash – There is a small amount of trash (bottles, cans) scattered within the unit. A periodic cleanup by volunteers is recommended.

Hazards – There are a few potential hazards in close proximity to each other within the unit (H5). The first is an old pit that is partially covered; the second is a nearby stone fireplace, which is currently an occasional party spot; and the third (50 feet north of the fireplace) is an old open manhole with a 2-foot drop. It is recommended that the well and manhole be filled with stone from the fireplace to eliminate all three hazards.

Southern Red Oak Forest

- **Size**: 7.3 acres

- **Description**: Predominantly a dry oak-mixed hardwood forest with some dry oak-heath on upper slopes. Located on the west side of the gorge, at the southern tip of College property. See Section 1.2.1.1 for a detailed description of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Sparse due to deer browsing. This unit shows one of the highest deer impact levels (clear browse line, no oak seedlings) in the Crum Woods. This

impact jeopardizes the perpetuation of this ecologically important community. It is recommended that measures be taken as soon as possible to establish regeneration. Recommended steps include reducing the deer population to 5 to 10 per square mile (2 to 4 km^{-2}) and installing deer fencing around at least half of the unit. See Appendix I for information on controlling deer populations.

Invasive plants – Currently free of invasives, although several species, including Japanese stilt grass, Japanese honeysuckle, Japanese knotweed, ailanthus, and mile-a-minute are poised on the edge of this unit. Given its ecological value, the area deserves close monitoring and quick action to prevent intrusion by invasive species. Afforestation of the current composting facility would also help to buffer this area from edge effects. See Appendix J for information on controlling invasive plants.

Trails – Part of the informal trail system on the west side of the gorge loops through the unit. It is recommended that this not become part of a formal trail system (if established) and that recreational use of this area be discouraged to minimize disturbance and the potential to spread seeds of invasive plants.

Trash – There is a small amount of trash (paper, bottles, plastic) scattered within the unit. A periodic cleanup by volunteers is recommended.

Dumping – The border with the composting facility (D5) has been used as a location for dumping old construction material including soil, concrete and stone. This practice visually degrades the area and provides establishment sites for invasives. It is recommended that this material be removed and the College find a more appropriate place to dispose of or recycle waste material.

Martin Forest

- **Size**: 22.7 acres

- **Description**: Predominantly a hemlock (white pine)-red oak-mixed hardwood forest with some tuliptree-beech-maple forest on the lower slopes and alluvial flats. See Section 1.2.1.1 for a detailed description of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing and a dense overstory; satisfactory in gaps at present. There is evidence of moderate to heavy deer browsing in some areas, particularly on the upper slopes where a distinct browse line is visible. To protect and enhance existing regeneration it is recommended that the College monitor and coordinate with the Delaware County Department of Parks and Recreation and Pennsylvania Game Commission to control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

Invasive plants – Impact ranges from none to moderately severe. The highest impact is along the utility right-of-way and the northeastern boundary, particularly near the residential development. Problem species include Norway maple, oriental bittersweet, garlic-mustard and Japanese stilt grass. Given the ecological significance of this unit and the generally low level of impact, it is recommended that invasives be managed, starting in the interior and moving to the edge, as soon as possible to prevent further spread within the unit. It is recommended that invasives should then be monitored annually and managed as needed. See Appendix J for information on controlling invasive plants.

Trails – Generally in good condition although a higher level of maintenance is needed for the current level of use (see Appendix K for trail maintenance guidelines). Mountain bikers are using the trails although at the current level of use they are not significantly damaging the trail. The planned creation of a parking lot near the Blue Route overpass for new soccer fields on an adjacent property will no doubt increase the use of the trail through Martin Forest. This increase in use and associated wear and tear on the trail will require an increased level of maintenance. It will also make use by bikes more problematic in that the narrow trail will not be able to safely accommodate both uses. There are currently several areas that require a combination of regrading or waterbars and rerouting to retire highly eroded trail areas. In addition, a small bike jump just north of the powerline right-of-way should be removed along with a large tree that is blocking the northern end of the trail and causing trail users to cut across a steep bank. It is recommended that permanent trails be established, marked, and maintained regularly to minimize the creation of new trails and the associated disturbance to the forest.

Trash – There is a small amount of trash (bottles, plastic, metal, cans) scattered within the unit. A periodic cleanup by volunteers is recommended.

Unwarranted use – There may be unwarranted use in several areas along the eastern border. Residents of the development to the north are dumping yard waste and construction debris along the property line, in some cases probably within the property (U4, U5). There also may be intrusion (cutting of trees) by the golf course along this same border (U6, U7). To resolve these issues and identify the borders to all stakeholders, it is recommended that the boundary (except for that adjacent to Crum Creek) should be surveyed, posted with appropriate signage and periodically monitored. If the survey reveals that there is indeed unwarranted use, the neighbors should be informed and appropriate measures taken, including removal of debris and replanting..

5.1.2 Other Upland Forests

Northeast Forest Area

- **Size**: 2.0 acres

- **Description**: Located at the tip of the main body of the Campus Woods between Crum Creek and Wallingford and Ogden Roads on the east side of the gorge. Predominantly tuliptree-beech-maple forest. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing, a dense overstory and invasive groundcovers; satisfactory in gaps at present. Deer pressure is likely low in this area due to high levels of human use, but there are initial signs (high proportion of spicebush, browse on blackgum rootsprouts) of deer impact. To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Heavily impacted by invasives including Norway maple, Japanese honeysuckle, winged euonymus, wintercreeper, and Amur honeysuckle. Initial focus should be on the removal of the scattered individuals of invasive trees (Norway maple) and shrubs (winged euonymus) to provide more sunlight for native tree regeneration. See Appendix J for information on controlling invasive plants.

  Trails – The trail through this unit provides access from Wallingford Road. This would be a good location for signage to inform users of recreational opportunities and allowed uses of the Woods and to provide a trail map.

  Hazards – The unit closely borders residential structures. It is recommended that the areas of the unit bordering these structures be part of an annual hazard-tree monitoring program.

Elm Avenue Cove

- **Size**: 4.0 acres

- **Description**: Located on the east side of the gorge, south and west of the terminus of Elm Street. A combination of dry oak-mixed hardwood forest and tuliptree-beech-maple forest. See Section 1.2.1.1 for a detailed description of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing, a dense overstory and invasive groundcovers; satisfactory in gaps at present. Deer pressure is likely low in this area due to high levels of human use, but there are initial signs (high proportion of spicebush, browse on blackgum rootsprouts) of increasing deer impact. To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Generally light impact by invasives. The northwest corner of the forest is moderately invaded by English ivy, pachysandra, goutweed and Japanese honeysuckle. Initial focus should be on the removal of the scattered individuals of invasive trees (Norway maple, corktree) and shrubs (Japanese angelica-tree) to provide more sunlight for native regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present.) See Appendix J for information on controlling invasive plants.

  Trails – Generally in good condition although a higher level of maintenance is needed for the current level of use (see Appendix K for trail maintenance guidelines). The main trail from the Science Center requires new and additional waterbars. It is recommended that one section of the main trail be rerouted to retire a highly eroded trail area. The trail to Elm Avenue crosses a small stream that drains the cove. Silt from trail disturbance compromises the water quality of the stream. A set of stepping stones or a small culvert at the stream would reduce this impact. The latter solution would probably be best if bike traffic is likely to continue on the trail.

  Public use – The trails through this unit include two of the main access points to Crum Woods for members of the College community (behind the Science Center) and neighbors (at the end of Elm Avenue). These would be good locations for signage to inform users of recreational opportunities and allowed uses of the Woods and to provide a trail map. The College should gain formal approval from the property owner at the end of Elm Avenue to maintain the section of trail that connects College lands with the public road.

  Trash – There is a small amount of trash (bottles, plastic) scattered within the unit. A periodic cleanup by volunteers is recommended.

  Hazards – The unit closely borders residential structures and facilities that are used regularly by the College community. It is recommended that the areas of the unit bordering these facilities be part of an annual hazard-tree monitoring program.

Amphitheater Forest

- **Size**: 4.7 acres

- **Description**: Located on the east side of the gorge, west of the Amphitheater. Predominantly a tuliptree-beech-maple forest. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing, a dense overstory and invasive groundcovers; satisfactory in gaps at present. Deer pressure is likely low in this area due to a high level of human use. To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Intermediate impact by invasives, particularly English ivy. Also present are Norway maple, sweet cherry, Japanese stilt grass, garlic-mustard and mile-a-minute. Initial focus should be on the removal of the scattered individuals of invasive trees (Norway maple, sweet cherry) to provide more sunlight for native regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present.) See Appendix J for information on controlling invasive plants.

  Trails – Generally in good condition although a higher level of maintenance is needed for the current level of use (see Appendix K for trail maintenance guidelines). It is recommended that new waterbars be installed in two locations along with a footbridge and that a section should be rerouted to retire a badly eroded area (see Figure 18). There are also areas with loose pieces of asphalt that should be removed.

  Public use – Several trailheads used mainly by students are located in this unit. This would be a good location for signage to inform users of recreational opportunities and allowed uses of the Woods and to provide a trail map.

  Trash – There is a small amount of trash (cans, paper) scattered within the unit. A periodic cleanup by volunteers is recommended.

  Hazards – The unit closely borders facilities that are used regularly by the College community. It is recommended that the areas of the unit bordering these facilities be part of an annual hazard-tree monitoring program.

Northwest Forest Area

- **Size**: 28.5 acres

- **Description**: Located mostly on the mid- and upper slopes on the west side of the gorge, to the north of the railroad trestle. Includes the forest around the Clarke House and 445 Rogers Lane. A combination of red oak-mixed hardwood forest, tuliptree-beech-maple forest, and forest with strong presence of introduced species. See Sections 1.2.1.1 and 1.2.1.3 for detailed descriptions of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally sparse due to deer browsing and a dense overstory (subcanopy of Norway maple and American beech); barely adequate in most gaps (mostly Norway maple, sugar maple, American beech) at present. There are signs of high deer pressure (high proportion of spicebush in shrub layer, numerous trails). To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Intermediate to severe impact by invasives, particularly Norway maple, oriental bittersweet, Japanese honeysuckle, and garlic-mustard. Also present are goutweed, winged euonymus, corktree and bamboo. Initial focus should be on cutting invasive vines overtopping the foliage of canopy trees (starting in the interior and moving to the edge) and on the removal of the invasive trees (Norway maple, corktree) and shrubs (winged euonymus) to provide more sunlight for native regeneration. Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaed akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. (Workers will need to distinguish Norway maple from sugar maple, which is also present.) See Appendix J for information on controlling invasive plants.

  Trails – The trails within this unit are haphazard with low use and little or no maintenance. It is recommended, as part of the general review of the trail system that a continuous and permanent trail be established and marked to minimize the creation of multiple ephemeral trails and the associated disturbance to the forest.

  Unwarranted use – The residents of the Clarke House have traditionally used the adjacent forest as a disposal site for yard waste and other debris (U2). This is not only unsightly, but can potentially compromise forest health by covering understory plants and introducing toxic substances and invasive plants. This practice should be prohibited and the material removed for appropriate disposal.

There is also possible encroachment (dumping, use as a landscaped area) along the southeast boundary of the neighboring, privately owned property at 331 Rogers Lane, just west of the Clarke House (U3). It is recommended that the entire western boundary of this unit be surveyed and marked to confirm or disprove this encroachment, to prevent future encroachment from the numerous adjacent residential properties, and to prevent future recreational and pedagogical users of the Woods from intruding onto private property. Any dumped material found to lie within the College boundary should be removed.

Trash – There is a small amount of trash (cans, metal, plastic, bottles) scattered within the unit. A periodic cleanup by volunteers is recommended. There is also a small, old dump site (D1) containing concrete and assorted metal (pipes, a gate). The surface material should be removed as part of a general cleanup of the unit.

Hazards – There are a few obsolete or hazardous structures within this unit. In the northeast corner of the Clarke House complex (H3) are two old outbuildings that are a potential attractive nuisance. It is recommended that they be either maintained or removed. Also, in the southwest section of this unit is an old 10-foot diameter stone structure (H4) with an open roof, possibly a springhouse or root cellar. The rear wall of the structure is recessed into the slope and creates an 8-foot drop into the structure, which is a hazard to both humans and wildlife. It is recommended that this structure either be secured (new roof and door) or removed. Also, the unit closely borders residential structures in a few areas. It is recommended that the areas of the unit bordering these structures be part of an annual hazard-tree monitoring program.

Southwest Forest Area

- **Size**: 27.9 acres

- **Description**: Located mostly on the mid- and upper slopes on the west side of the gorge south of the railroad trestle. It includes the forest around the Castanea House and composting facility. A combination of red oak-mixed hardwood forest, tuliptree-beech-maple forest, conifer plantation, and forest with strong presence of introduced species. See Sections 1.2.1.1 and 1.2.1.3 for detailed descriptions of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally sparse due to deer browsing, a dense overstory (subcanopy of Norway maple and American beech) and invasive groundcovers; barely adequate in most gaps (mostly Norway and sugar maple) at present. There are signs of high deer pressure (high proportion of spicebush in shrub layer, numerous trails). To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate

density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

Invasive plants – The impact of invasives ranges from none to severe. Two areas of severe impact are between the railroad trestle and Castanea House and between the Scott Arboretum nursery and the composting facility. The most problematic species within this unit include Norway maple, oriental bittersweet, pachysandra, and English ivy. Also present are privet, periwinkle, five-leaved akebia, winged euonymus, garlic-mustard, corktree, mile-a-minute, grape, Japanese honeysuckle, Japanese stilt grass and Japanese angelica-tree. See Appendix J for information on controlling invasive plants. Initial focus should be to cut invasive vines overtopping the foliage of canopy trees (starting in the interior and moving to the edge of the unit) and on the removal of the invasive trees (Norway maple) and shrubs (privet, winged euonymus) to provide more sunlight for native regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present.) Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. A dormant season spraying of the evergreen invasive groundcovers should also be considered.

Trails – Trails in this area are informal paths and deer trails that receive low to moderate use and little or no maintenance. There are an excessive number of trails and some sections are poorly located. It is recommended that permanent trails be established (the number of trails should be reduced), marked, and maintained regularly to minimize the creation of new trails and the associated disturbance to the forest. The general public can access the Campus Woods from the Leiper Trail, which runs adjacent to this unit. If the College wishes to connect Crum Woods trails with the Leiper Trail, it is recommended that two official entrances be established to create a loop and that other entry points be closed. At these points the College should consider installing signage to inform users of recreational opportunities and allowed uses of the Woods and to provide a trail map.

Hazards –The ruins of Hinkson's Water Garden (H6) north of Castanea House are an attractive nuisance and are easily accessible from the Leiper Trail. The College should consider either restoring this area with appropriate safety precautions or eliminating this hazard. Two other potential hazards are an old chainlink fence (H7) between the garden ruins and Castanea House and an old open cistern (5 ft. deep, 5 ft. wide; H9) on the slope below the composting facility. It is recommended that the College remove the fence and fill the cistern with native rock. It is also recommended that the area around the sitting area off the Leiper Trail be part of an annual hazard-tree monitoring program.

Trash – There is a small amount of trash (cans, metal, plastic construction fencing, bottles) scattered within the unit. A periodic cleanup by volunteers is recommended.

Composting facility – The composting facility has significant impacts on the Crum Woods. It contributes significantly to the fragmentation of the forest. The College is using the perimeter of the site as a disorganized storage and disposal area (D5) for old construction material (soil, stone, concrete). The detention basin designed to handle runoff from the facility is not functioning properly. As a result, gully erosion is starting within the adjacent forest (E2). For the long-term benefit of the forest and the pedagogical potential of the Woods, the College should seriously consider terminating both uses and restoring this area to forest. In the short term, it is recommended that debris piles be removed from the site and that more effective stormwater control structures be established (contact the Delaware County Conservation District for recommendations) between the paved composting platform and the forest. Disturbance related to any continued activity should be located no closer than 50 feet from the forest edge to prevent damage to edge trees.

Old Mill House – The Old Mill House lies at the southern tip of this forest. This 3-acre disturbed area provides fertile ground for invasive species to become established and threaten forest health. It could, however, have the potential to support stewardship of the Crum Woods by providing a residence for stewardship or research personnel. It is recommended that the College consider using this asset as a benefit to future stewardship personnel.

Southeast Forest Area

- **Size**: 13.8 acres

- **Description**: Located mostly on the mid- and upper slopes on the east side of the gorge south of the railroad trestle. Includes the forest around the Frorer Holly Collection, Crum Ledge apartments and Wister's Garden. A combination of red oak-mixed hardwood forest, tuliptree-beech-maple forest, and forest with strong presence of introduced species. See Sections 1.2.1.1 and 1.2.1.3 for detailed descriptions of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing and a dense overstory (subcanopy of American beech, Norway and sugar maple) and competition with invasives; the few existing stems within existing gaps are being smothered by invasive vines. There is evidence of moderate deer browsing (start of a browse line; high proportion of spicebush) in some areas. To protect and enhance existing regeneration it is recommended that the College monitor and control the local

deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

Invasive plants – Impact is mostly intermediate to severe. Two small areas with no invasives exist north of Skunk-cabbage Hollow. Most problematic within this unit are invasive vines including grape, oriental bittersweet, English ivy and Japanese honeysuckle which are present both at the forest edge and within gaps. This situation is a harbinger of how invasives will gradually spread from forest gaps in the remainder of Crum Woods as canopy trees periodically fall. It is recommended that an initial focus within this unit should be the control of invasive vines, working from the interior to the edge. Introduce vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. Another recommended priority is to continue the removal of invasive trees (Norway maple) and shrubs (linden viburnum, Japanese angelica-tree) to provide more sunlight for native tree regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present in the unit.) See Appendix J for information on controlling invasive plants.

Trails – Trails in this area are generally in fair to good condition and in appropriate locations; however, there are a few unneeded or unwanted trails. A higher level of maintenance is needed for the current level of use (see Appendix K for trail maintenance guidelines). There are a few areas that require new and additional waterbars and a section just south of Wister's Garden that should have steps or a railing. It is recommended, as part of the general review of the trail system, that permanent trails be established (the current number appears to be appropriate) and marked to minimize the creation of multiple trails and the associated disturbance to the forest. Excess trails should then be closed. If the College decides to allow some bike use within the Crum Woods, the trails in this unit could be part of a trail loop from the road below Crum Ledge to the railroad trestle, the location that could best accommodate this use. Both the College community and the general public access the Woods from several trailheads in this unit; the most heavily used may be at the gate to the unpaved road to Crum Meadow, along Field House Lane just west of the squash courts. As part of establishing permanent trails, the College should consider installing signage to inform users of recreational opportunities and allowed uses of the Woods and to provide a trail map.

Trash – There is a small amount of trash (paper, cans, bottles) scattered within the unit. A periodic cleanup by volunteers is recommended.

Dumping – There is old construction debris (stone, concrete) along the border with Crum Meadow (D3). It is recommended that at least the surface concrete be removed. Small piles of soil, concrete and asphalt were observed along the old

access road running from Crum Ledge Lane to Skunk-cabbage Hollow (D5), a few of recent origin. It is recommended that a more appropriate site be found for disposal of waste material and that all contractors and facilities and maintenance staff be advised that dumping in this and other sections of Crum Woods is prohibited. The College should consider erecting a barrier to vehicular use of the old road to further discourage disposal in this area.

Hazards – There are two minor potential hazards within the unit (see Figure 18) along the trails. The first is an old 4-inch metal pipe that crosses the trail between Wister's Garden and Crum Ledge (H10). If this pipe (a tripping hazard) is no longer functioning it is recommended that it be removed. There is also a 4-ft.-diameter hole recently created by the windthrow of a large tree (H8) on the same trail just north of where it connects with the trail leading to Crum Meadow.

Yale Avenue Forest

- **Size**: 4.4 acres

- **Description**: Predominantly a red oak-mixed hardwood forest on mid- and lower slopes south of Yale Avenue. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited (mostly American beech sprouts and sugar maple) due to deer browsing and a dense overstory. Given the proximity of residential structures and a busy public road, it would be difficult to implement any management of the deer population in this unit.

  Invasive plants – Overall impact of invasives is moderately severe, with the greatest impact along the road edge. Problem species include oriental bittersweet and wisteria. Other invasives include Japanese stilt grass, Japanese honeysuckle, mile-a-minute and Norway maple. It is recommended that the initial focus of control be on cutting invasive vines overtopping the foliage of canopy trees. Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. See Appendix J for information on controlling invasive plants.

  Trails – The generally steep slopes of the unit and the need to cross a busy public road make including this unit in the current trail system problematic.

  Trash – There is a moderate amount of trash (cans, metal, glass, ceramic plates) and old construction material (stone, bricks, asphalt) scattered within the unit. A periodic cleanup by volunteers is recommended.

Hazards – The unit has approximately 1,400 feet of road frontage along Yale Avenue. Many of the large canopy trees lean toward this road. It is recommended that this unit be part of an annual hazard-tree monitoring program. There is also a 5 to 10-foot high stone wall behind the Mary Lyon faculty apartments (Mary Lyon 4) which is actively deteriorating (H13). Stones are falling on the steep bank and rolling through the forest toward the public road. Although the forest vegetation will intercept many of the stones, the height of the wall and steepness of the slope provide some potential for stones to reach the road, particularly if a large section were to collapse. It is recommended that qualified personnel inspect the wall to determine the appropriate measures to stabilize or remove this hazard.

Martin Forest Tributary Valley

- **Size**: 5.6 acres

- **Description**: Predominantly a tuliptree-beech-maple forest on lower slopes adjacent to an unnamed tributary of Crum Creek, within the Martin Forest. See Section 1.2.1.1 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing and a dense overstory (subcanopy of Norway maple and American beech); barely adequate in gaps at present. Evidence of moderate to heavy deer browsing in some areas including a high proportion of spicebush and a clear browse line in the northern section. To protect and enhance existing regeneration it is recommended that the College monitor and coordinate with the Delaware County Department of Parks and Recreation and Pennsylvania Game Commission to control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Impact ranges from none to moderately severe. Problem species include oriental bittersweet, Norway maple and Japanese honeysuckle. Also present are Amur honeysuckle, sweet cherry and Japanese barberry. Initial focus should be cutting invasive vines overtopping the foliage of canopy trees (starting in the interior and moving to the edge of the unit) and on the removal of the invasive trees (Norway maple, sweet cherry) and shrubs (honeysuckle, barberry) to provide more sunlight for native regeneration. (Workers will need to distinguish Norway maple from sugar maple, which is also present.) Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. See Appendix J for information on controlling invasive plants.

Trails – Generally in good condition although a higher level of maintenance is needed for the current level of use (see Appendix K for trail maintenance guidelines). The planned creation of a parking lot 2,000 feet south of this unit (next to and beneath the Blue Route overpass) will no doubt increase the use of the trail through Martin Forest. This increase in use and associated wear and tear on the trail will require an increased level of maintenance. It is recommended that the trail be marked and maintained regularly to minimize the creation of new trails and the associated disturbance to the forest.

Trash – There is a small amount of trash (cans, metal, glass, tires) scattered within the unit. A periodic cleanup by volunteers is recommended.

5.2 WETLAND FORESTS

5.2.1 Core Floodplain and Swamp Forest Natural Areas

Oxbow Swamp Forest

- **Size**: 2.3 acres

- **Description**: A combination of red maple-mixed shrub palustrine woodland and sycamore-(river birch)-boxelder floodplain forest/woodland. See Section 1.2.1.2 for a detailed description of these forest communities. Located on the west side of Crum Creek, north of the railroad trestle.

- **Management issues and recommendations**:

  Tree regeneration – Generally adequate at present. Monitor and control deer population. See Appendix I for information on controlling deer populations.

  Invasive plants – Generally light impact of invasives which include Norway maple, multiflora rose, and privet. Vine species (grape, oriental bittersweet) are established on the western edge of this unit. Given its ecological value, the area deserves close monitoring and quick action to prevent intrusion by invasive species. See Appendix J for information on controlling invasive plants.

  Trash – There is an old dump site on the southwest edge of this unit containing old appliances, metal, plywood and glass (D2). There is also scattered trash (bottles, plastic) as a result of flooding. It is recommended that at least the surface material in the dump be removed along with the scattered trash.

Skunk-cabbage Hollow

- **Size**: 2.7 acres

- **Description**: Located on the east side of Crum Creek, south of Crum Ledge. A combination of red maple-mixed shrub palustrine woodland, sycamore-(river birch)-boxelder floodplain forest/woodland, and mixed forb marsh. See Sections 1.2.1.2 and 1.2.2.1 for detailed descriptions of these forest communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally sparse due to deer browsing. There are signs of high deer pressure (high proportion of spicebush in shrub layer). To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Intermediate impact, particularly in the shrub layer where privet, Amur honeysuckle and multiflora rose are well established and act as habitat for numerous migratory and breeding birds. Control of these species will need to proceed gradually to avoid causing significant adverse impacts on bird habitat. Starting at the perimeter of the invaded area, it is recommended that native shrub species appropriate to the site (e.g., winterberry holly, arrow-wood) be planted as invasive species are removed. Limit disturbed area to no more than about 10% of the contiguous area of any one plant community occurrence (i.e., each polygon on the Plant Communities maps, Figures 4 and 5) in any one year. Wait until planted areas are established before proceeding to the next area. The marsh has a small colony of phragmites. It should be removed as soon as possible. If left unchecked, phragmites often spreads and destroys wetlands' native biological diversity. Given its ecological value, the area deserves close monitoring and quick action to prevent further intrusion by invasive species. See Appendix J for information on controlling invasive plants.

  Trails – Trails in this area are in generally good condition and are not excessive although there are a few outlaw trails. The main trail would be part of a trail loop (from the road below Crum Ledge to the railroad trestle) that would be the most appropriate location in the Crum Woods for bike use. It is recommended, as part of the general review of the trail system, that permanent trails be established and marked to minimize the creation of multiple trails and the associated disturbance to the forest.

  Trash – There is a small amount of trash (plastic, bottles) scattered within the unit. A periodic cleanup by volunteers is recommended.

  Dumping – This area was a major dump site for old construction material, including old concrete curbing (D5), metal and concrete culvert pipe, asphalt and bricks. The largest area is a half-acre site near Crum Creek (D4) containing

asphalt, bricks, and other construction material. This material not only degrades the area visually, but it also modifies the hydrology that supports this valuable community. It is recommended that the College eventually remove all the dumped material from this unit to increase its ecological value. Potential funding sources for removing the large dump and restoring native wetland vegetation include the Pennsylvania Department of Environmental Protection's Growing Greener Program and wetland mitigation projects.

5.2.2 Other Wetland Forests

Martin Palustrine Forest

- **Size**: 2.8 acres

- **Description**: A sycamore-(river birch)-boxelder floodplain forest/woodland located at the southern tip of the Martin Forest. See Section 1.2.1.2 for a detailed description of this forest community.

- **Management issues and recommendations**:

  Tree regeneration – Sparse due to deer browsing. To protect and enhance existing regeneration it is recommended that the College monitor and control the local deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Invasive plants – Light to intermediate impact from invasives, including oriental bittersweet, multiflora rose, privet, Norway maple, Japanese stilt grass, black bindweed and mile-a-minute. Initial focus should be cutting invasive vines overtopping the foliage of canopy trees (starting in the interior and moving to the edge of the unit) and on the removal of the invasive trees (Norway maple) and shrubs (privet, multiflora rose) to provide more sunlight for native regeneration. Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. See Appendix J for information on controlling invasive plants.

  Trails – The section of trail that provides access to the creek in the northern section of this unit is badly eroded. It is recommended that this section be retired and a new trail be cut to the creek's bank.

  Parking lot – A parking lot for adjacent athletic fields is planned for the open area adjacent to and under the Blue Route. Minimizing the impact to the forest will require informed review of the plans and close monitoring of disturbed areas both during and after construction, primarily to watch for and block the establishment of invasive plants.

Trash – There is a small amount of trash (cans, plastic) scattered within the unit, mostly from flooding. A periodic cleanup by volunteers is recommended.

Campus Woods Riparian Forest

- **Size**: 22.6 acres

- **Description**: Located on the lower slopes and flat areas adjacent to Crum Creek and its major tributary, Dicks Run. Predominantly sycamore-(river birch)-boxelder floodplain forest; contains a small area of mixed forb marsh near the Wallingford Road bridge. See Sections 1.2.1.2 and 1.2.2.1 for detailed descriptions of these communities.

- **Management issues and recommendations**:

  Tree regeneration – Generally sparse due to deer browsing, dense overstory (subcanopy of Norway maple and American beech) and invasive groundcovers; barely adequate in gaps (mostly Norway and sugar maple) at present. The heavy dominance of spicebush in the shrub layer in some areas and other signs of browsing indicate growing deer pressure. Monitor and control deer population to an appropriate density (5 to 10 per sq. mi. [2 to 4 km^{-2}]). See Appendix I for information on controlling deer populations.

  Riparian buffer – There are two areas, adjacent to Crum Meadow and below the Strath Haven Condominium meadow, where the forest exists only as a narrow, discontinuous band of trees along Crum Creek. Efforts are underway in both areas (planting trees at Crum Meadow; allowing lawn to succeed to meadow below the condominium site) to enlarge the riparian buffer for Crum Creek. It is recommended that these efforts continue with a goal of eventually establishing a forested riparian buffer with a width of at least 75 feet.

  Invasive plants – Intermediate to severe impact, particularly Japanese knotweed, privet and Norway maple. Other species include oriental bittersweet, mile-a-minute, phragmites, English ivy, grape, Japanese honeysuckle, Japanese angelica-tree, linden viburnum, purple loosestrife and winged euonymus. See Appendix J for information on controlling invasive plants. Initial focus should be on cutting invasive vines overtopping the foliage of canopy trees and removing invasive trees and shrubs to provide more light for native tree and shrub regeneration. Introduced vine species (English ivy, oriental bittersweet, Japanese honeysuckle, five-leaved akebia, wisteria) should be cut when they start to climb on trees; grape (all species now present in the Crum Woods are native) should only be cut when it starts to overtop the foliage of canopy trees. Control of shrub species will need to proceed gradually to avoid significant impacts on bird habitat. Starting at the perimeter of the invaded area, it is recommended that native shrub species appropriate to the site (e.g., winterberry holly, arrow-wood) be planted as invasive species are removed. Limit disturbed area to no more than about 10% of

the contiguous area of any one plant community occurrence (i.e., each polygon on the Plant Communities maps, Figures 4 and 5) in any one year. Wait until planted areas are established before proceeding to the next area.

Trails – Trails are in generally good condition and are not excessive. It is recommended, as part of the general review of the trail system, that permanent trails be established and marked to minimize the creation of multiple trails and the associated disturbance to the forest. The general public accesses the Campus Woods from the part of this unit that borders Yale Avenue. The College should consider installing signage to inform users of recreational opportunities and allowed uses of the Woods and to provide a trail map at the point where the trail enters the forest.

Trash – Assorted trash is deposited during periodic flood events. The College should monitor accumulations after storms and remove as much as practical to limit the aesthetic impact.

Hazards – There are a few potential hazards within the unit, both located near the Old Mill House in the southern end of Campus Woods. The first is an old brick foundation (H11) approximately 15 ft. by 35 ft. in size and 6 ft. deep which presents a fall hazard. It is recommended that the foundation (and remains of a metal fence) be imploded and the area regraded and planted to native trees. The second potential hazard is the millrace (H12) associated with the Old Mill House, which also presents a fall hazard. It is recommended that it be restored with appropriate safety precautions or buried. Because of the historical and potential archaeological significance of the site (see Section 1.1.5), no hazard-management actions should be taken without a thorough prior review by qualified historians and archaeologists. The portions of this unit on both the northern and southern ends of Campus Woods lie adjacent to public roads; it is recommended that these areas be part of an annual hazard-tree monitoring program.

5.2.3 Other Wetland Forests / Meadows / Shrublands

Pipeline Rights-of-way

- **Size**: 1.5 acres

- **Description**: Two 50 ft.-wide rights-of-way located in the northwest corner of the Campus Woods adjacent to Crum Creek and in the northern half of Martin Forest. The former is predominantly upland/wet mowed turf; the latter is predominantly successional thicket. See Section 1.2.2.2 for detailed descriptions of these forest communities.

- **Management issues and recommendations**:

  Invasive plants – Invasives within these areas are somewhat controlled by periodic mowing, although Japanese stilt grass dominates the Campus Woods right-of-way. Also, because they are maintained in an open state, they have a significant impact on the adjacent forest by providing edge habitat for invasives to become established and spread into the forest. The edge of the Campus Woods right-of-way is dominated by mile-a-minute (forest side) and Japanese knotweed (Creek side). The right-of-way through the Martin Forest is mowed at multi-year intervals allowing light to moderate growth of Japanese stilt grass, multiflora rose, oriental bittersweet, ailanthus and Japanese angelica-tree. It is recommended that the Campus Woods right-of-way be converted to a warm-season grass and wildflower meadow to create some educational and ecological benefit from this unavoidable scar on the landscape. Native grasses and wildflowers should be planted using seed only of genotypes native to the mid-Atlantic region. See Appendix L for information on establishing and maintaining native warm-season grass and wildflower meadows.

5.3 MARSH AND SHRUB SWAMPS

5.3.1 Core Marsh and Shrub Swamp Natural Areas

Oxbow Marsh and Shrub Swamp

- **Size**: 1.7 acres

- **Description**: Located on west side of Crum Creek, north of railroad trestle. A combination of black willow scrub/shrub wetland and mixed forb marsh. See Section 1.2.2.1 for a detailed description of these communities.

- **Management issues and recommendations**:

  Invasive plants – Moderate impact by invasives, principally phragmites and grape. The invasion is spreading but the affected area is still small enough that a qualified supervisor and a few volunteers could eliminate it in a half-day's effort each year for two or three years and less often thereafter. If left unchecked, past experience elsewhere indicates that it will soon become a problem of such magnitude that a solution would be too expensive, time-consuming, and destructive to contemplate; the wetlands' native biological diversity would be irretrievably lost. See Appendix J for information on controlling invasive plants.

5.4 MEADOWS / SHRUBLANDS

Crum Meadow
Crumwald Farm and Clarke House
Strath Haven Condominiums
Swarthmore Farm Plateau
Scott Arboretum Nursery

- **Size**: 10 acres

- **Description**: Open areas adjacent to College facilities. A combination of herb-dominated old field/road cut, upland/wet mowed turf, upland meadow, and wet meadow. See Section 1.2.2.2 for detailed descriptions of these communities.

- **Management issues and recommendations**:

  Invasive plants – Light to intermediate impact from invasives including black bindweed, Canada thistle, and mile-a-minute; invasives within these areas are somewhat controlled by periodic mowing. However, the extensive edge created by these communities has a significant impact on the adjacent forest by providing edge habitat for invasives, particularly invasive vines, to become established. Because of this impact, a review of the use of these areas is recommended. If possible, all uses that require open area should be consolidated away from the adjacent forest (Swarthmore Farm Plateau, Arboretum nursery, Clarke House) or Crum Creek (Crum Meadow, Strath Haven Condominiums).

  Riparian buffer – Half of these areas border Crum Creek. Water quality could be improved by continuing and expanding the effort to create a forested riparian buffer by planting a strip (at least 75 ft. wide) of trees and shrubs along the creek. This will help to lessen streambank erosion and provide shade for the stream. Funding may be available through the Pennsylvania Department of Environmental Protection's Growing Greener Program.

  Native biodiversity – Most of this unit is dominated by exotic grasses. It is recommended that the College convert the areas that will remain open (and are not used for passive recreation by the College community) to native warm-season grass and wildflower meadows (see Appendix L). This will increase biodiversity and provide enhanced habitat for native fauna (birds, small mammals, butterflies and other insects). Native grasses and wildflowers should be planted using seed only of genotypes native to the mid-Atlantic region.

5.5 LANDSCAPED / CULTURALLY MODIFIED AREAS

Baltimore Pike Parcel

- **Size**: 4.2 acres

- **Description**: A combination of conifer plantation, upland mowed turf, sycamore-(river birch)-boxelder floodplain forest/woodland, and tuliptree-beech-maple forest. See Sections 1.2.1.1, 1.2.1.2, 1.2.1.3, and 1.2.2.2 for detailed descriptions of these forest communities. It is located on the east side of Crum Creek, at the intersection of Wallingford Road and Victoria Road. The parcel is detached from the main body of Campus Woods by approximately 1,500 feet.

- **Management issues and recommendations**:

  Tree regeneration – Generally limited due to deer browsing and invasive groundcovers; barely adequate in gap. Given the proximity of residential structures, it would be prohibitively difficult to implement any management of the deer population in this unit.

  Invasive plants – Intermediate impact of invasives, including Japanese stilt grass (dominates open area), mile-a-minute, English ivy and Japanese knotweed. Also present are grape, Japanese honeysuckle, privet and Norway maple. See Appendix J for information on controlling invasive plants.

  Unwarranted use – Some dumping of yard waste by neighbors; there is also a regularly used party spot (U1) in the conifer plantation. If the College intends to maintain long-term ownership of this parcel, it is recommended that the boundary be surveyed, marked and periodically monitored.

  Trash – There is a moderate amount of trash (mostly beer cans and old lumber) associated with the party spot. Assorted trash (cans, glass, plastic) is also scattered throughout the parcel. It is recommended that the party spot be cleaned up and periodically monitored.

  Hazards – The unit closely borders several residential structures and a public road. It is recommended that the unit be part of an annual hazard-tree monitoring program. Also, there is a rope ladder attached to one of the trees at the party spot (U1), which could be an attractive nuisance to small children. It is recommended that it be removed as part of the general cleanup of the party spot.

  Appropriate ownership – To restore and manage this area properly will consume a significant amount of staff time — time that would be better spent on more environmentally and ecologically important areas of the Crum Woods. The College should consider using this parcel as an asset property and investigate the potential for sale to the neighbors or the township, or limited development of the site, with the proceeds going to a Crum Woods Stewardship Endowment.

- **Management issues and recommendations**:

  Regeneration – Generally adequate at present; limited in areas where rhododendrons are dense. Little sign of deer impact in this heavily used area.

  Invasive plants – An intermediate level of impact. Problem species include English ivy, garlic-mustard, oriental bittersweet, pachysandra, Japanese angelica-tree, and a shrubby bamboo. Initial focus should be cutting vines starting to climb on canopy trees and tree seedlings.

  Trails – There is an extensive trail system through this unit, which is in generally good condition. One section of trail (the northern trailhead near the athletic complex) is acting as a stormwater channel for water coming off the driveway accessing the athletic complex. This is starting to cause gully erosion on the downhill slope (E1). It is recommended that this trailhead be closed and that a low earthen berm be created in the turf at the eastern border of the unit to capture stormwater runoff and allow it to infiltrate into the soil. If the runoff from the driveway proves too great for this low-tech structure, the College should contact the Conservation District for advice on modifications to increase the holding capacity or infiltration rate.

  Trash – There is a very small amount of scattered trash within the unit. A periodic cleanup by volunteers is recommended. There is also an old sprinkler post with a concrete base next to a trail. It is recommended that this be removed if not still in use.

Crumwald Farm and Clarke House
Frorer Holly Collection
445 Rogers Lane
Houses South of Wister's Garden
Old Mill House
Crum Ledge
Castanea House
Composting Facility
Miscellaneous Facilities

- **Size**: 13 acres

- **Description**: A combination of structures and landscaped areas.

- **Management issues and recommendations**:

  Forest Fragmentation – These areas create holes within the natural forest which decrease the habitat value of the forest and invite invasion by opportunistic species, both flora (invasive species) and fauna (cats, cowbirds, raccoons). While most of these areas are "unmovable" (given the investment to establish and maintain them and their functions within the College community) the College

should consider a formal exercise to review each site to weigh its value to the College against maintenance costs and impacts on the Crum Woods. If the College makes a serious commitment to managing the Woods, they should consider using one of the house sites (the Castanea House may be geographically best suited and least intrusive to the Woods) as a residence for the manager to provide off-hours oversight to more remote areas.

Invasive plants – These areas (particularly those associated with the Arboretum) may be appropriate sites for exotic plants; however, Arboretum staff should continue its ongoing efforts to avoid introducing plants with either known or potential invasive characteristics. An emphasis on native species would, of course, minimize the potential threat to the Woods and provide some value to resident and migratory wildlife.

Water quality – A few of these sites are perched on steep slopes above Crum Creek. Currently, there are no problems related to stormwater runoff from impervious surfaces. Proper maintenance of stormwater structures should continue to prevent soil erosion and concomitant adverse impacts to water quality.

Hazards – Most of these areas are residential in nature. Their location within or adjacent to Crum Woods creates the potential hazard of a tree or tree limb causing personal injury or structural damage. It is recommended that all College residential areas be part of an annual hazard-tree monitoring program.

Table 8. Suggested prioritization of major recommendations for conservation and stewardship of the Crum Woods.

stewardship issue/recommendation	location	priority
Administration		
Establish administrative infrastructure to guide management and use	entire Crum Woods	1st
Secure permanent source of funding, e.g., a Crum Woods Endowment	entire Crum Woods	1st
Hire Crum Woods Manager	entire Crum Woods	1st
Institutionalize protection of Natural Areas, e.g., through sale of conservation easements	all Natural Area Cores and Natural Area Buffers	1st
Establish review and permitting protocol to minimize conflicts among curricular uses, research, and all other major uses	entire Crum Woods	2nd
Establish permanent system for tracking and disseminating information about annual curricular and research usage of the Woods	entire Crum Woods	2nd
Explore de-acquisition of Baltimore Pike and community gardens parcels	two small, disjoined Crum Woods tracts	2nd

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Table 8 (continued)

stewardship issue/recommendation	location	priority
Natural Resource Management		
Wildlife		
Establish a deer management program	throughout Crum Woods	1st
Install deer fencing to create exclosure area(s)	Southern Red Oak Forest	1st
Move machinery and material storage to north and west sides of composting facility, erect a barrier to prevent further incursion, and begin reforestation	strip of land between south and east sides of asphalt platform at composting facility and Southern Red Oak Forest Natural Area Core	1st
Convert excess lawn and meadows to native grass and wildflower meadows	Crum Meadow, Clarke House, Strath Haven Meadow, Swarthmore Farm Plateau	2nd
Invasive Plants		
Remove phragmites and replant herbaceous native marsh species	Oxbow Marsh and Shrub Swamp, Skunk-cabbage Hollow	1st
Control invasive vines	Hogback Knoll, Skunk-cabbage Hollow, Trillium Slope, Riparian Forest, Southeast Forest, inner edges of Southern Red Oak Forest Natural Area Buffer	1st
Remove invasive trees and shrubs affecting Natural Areas and replant native species	all Natural Area Cores and at least the inner 100-foot zone of Natural Area Buffers	1st
Control Japanese knotweed along Crum Creek and replant native riparian shrub species	Campus Woods Riparian Forest	2nd
Control invasive groundcovers	Trillium Slope, Elm Avenue Cove, Wister Forest	3rd
Remove invasive trees and shrubs not affecting Natural Areas and replant native species	(to be selected by Crum Woods Stewardship Committee or its appointees)	4th

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Table 8 (continued)

stewardship issue/recommendation	location	priority
Water Resources		
Address stormwater control at composting facility	Southwest Forest	1st
Increase forested riparian buffer	Campus Woods Riparian Forest, Crum Meadow, Strath Haven Meadow	1st
Initiate cleanup of old dump site through wetlands mitigation funding program(s)	Skunk-cabbage Hollow	1st
Address soil erosion	Wister's Garden	2nd
Community Use		
Develop use rules and regulations and means for enforcement	throughout Crum Woods	1st
Define trail system and mark	throughout Crum Woods	1st
Undertake trail improvements	Wister Forest, Elm Avenue Cove, Amphitheater Forest	1st
Work with Nether Providence Township to determine alternative location for composting facility	Southwest Forest, inner edges of Southern Red Oak Forest Natural Area Buffer	1st
Develop Crum Woods informational brochure and trail map including rationale and guidelines for respectful use	entire Crum Woods	1st
Survey boundary lines (except along Crum Creek)	Martin Forest, Northwest Forest	2nd
Install trailhead signage	at major entry points along Crum Woods perimeter	2nd
Dumping/Trash		
Remove debris piles on edge of composting facility	Southwest Forest	1st
Remove trash and debris piles	along entire Crum Woods boundary with neighboring properties	2nd

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Table 8 (continued)

stewardship issue / recommendation	location	priority
Potential Hazards		
Establish hazard-tree monitoring program	throughout Crum Woods	1st
Reset steps to Alligator Rock	Wister Forest	1st
Develop plan for safety upgrade and partial restoration (or removal) of Hinkson's Water Garden	Southwest Forest	1st
Remove or stabilize circular building	Northwest Forest	1st
Demolish stone chimney; fill pit and manhole	Trillium Slope	1st
Stabilize stone retaining wall behind Mary Lyon 4	Yale Avenue Forest	1st
Fill hole along trail	Southeast Forest	1st
Fill old cistern	Southwest Forest	2nd
Remove old brick foundation west of Mill House	Southwest Forest	2nd
Stabilize (or remove) old millrace structures	Southwest Forest	2nd
Remove old outbuildings at Clarke House	Northwest Forest	3rd
Remove old metal culvert	Wister Forest	3rd
Clean up party spot	Baltimore Pike Parcel	3rd

6.0 Monitoring Program

Section 5 highlighted the stewardship issues facing the Crum Woods today and provided recommendations based on current knowledge and technology. This information will have a limited shelf life due to the natural evolution of plant communities and the constant introduction of new environmental, ecological and human influences, some of them detrimental. In addition, our knowledge of natural systems like the Crum Woods will grow and new techniques and technologies will be developed to address management issues. Effective long-term stewardship of the Crum Woods will require not only resources to implement the restoration and maintenance recommendations above, but a systematic means of tracking the effects of management activities and of infusing new knowledge and technology into the management regime.

To most efficiently and effectively meet the conservation goals established in this and future management plans, it is recommended that the College carefully track environmental and ecological changes in the Crum Woods — those resulting both from management activities and from new influences on the property. With periodic feedback on which stewardship activities are or are not working, together with increased knowledge and new technologies, the College can continually adapt its management of the Woods to meet established conservation goals. This section will provide recommendations for a practical monitoring program designed to evaluate, routinely and systematically, progress toward achieving the College's conservation goals for the Crum Woods.

6.1 ADAPTIVE RESOURCE MANAGEMENT

The recommended approach is to use the modern decision-support concept of adaptive resource management (A.R.M.), which is a scientifically based way of "learning by doing." A.R.M. has been termed "managing in the face of uncertainty, with a focus on its reduction" (Williams and Johnson 1995). Implicit in this definition is that management can be improved if uncertainty is reduced. Summarized simply, A.R.M. involves five basic steps, which are repeated cyclically:

1. Determine (or review and update) conservation priorities for the property.

2. Set and quantify a resource management goal for each conservation priority.

3. Pick a set of management actions that are designed to move the system towards the goal.

4. Measure progress towards the goal at regular intervals (e.g., every three years) using indicator species and other environmental indicators.

5. Update the set of management actions based on the effectiveness of each action to move toward the goal.

6.2 POTENTIAL ADAPTIVE RESOURCE MANAGEMENT PLAN FOR THE CRUM WOODS

Section 2 highlighted the conservation priorities for the Crum Woods, generally grouped under programmatic priorities and ecosystem function priorities. Here we suggest goals, management actions, and measures of success for each priority. Developing and monitoring an adaptive resource management plan for the Crum Woods will offer many educational opportunities for students and faculty; some possibilities are noted below.

6.2.1 Programmatic priorities

6.2.1.1 Educational assets

- **Goal**: Sustain and enhance student pedagogical use of the Crum Woods.

- **Management actions**:

  Inform all faculty of existing resources and protocols for using the Crum Woods for research and education.

  Implement a system for avoiding conflicts in use of the Woods among faculty and between faculty and other users, and for resolving conflicts when they arise.

- **Measures of success**:

  Annual survey of faculty on uses of the Crum Woods.

  Annual catalog of instances of conflict in use of the Woods among faculty or between faculty and other users.

6.2.1.2 Good stewardship as an act of social responsibility

- **Goal**: Use the Crum Woods to instill a sense of social responsibility .

- **Management actions**:

  Encourage volunteer stewardship work.

  Utilize Crum Woods stewardship a real-world example of current environmental and social issues.

- **Measures of success**:

  Tracking volunteer hours.

  Annual surveys of faculty and of student organizations on their examination of, and participation in, Crum Woods stewardship in classes, seminars, student projects, discussions, and volunteer work.

6.2.1.3 Opportunities for passive recreation and contemplation for the College (and local) community

- **Goal**: Facilitate passive recreational activities that do not significantly degrade the Crum Woods.

- **Management actions**:

  Establish and maintain walking-trail system.

  Inform College and local communities of use rules through brochures, trailhead signs (potential communications curriculum project).

- **Measures of success**:

  Periodic sampling of numbers and types of users (potential statistics curriculum project).

  Sampling and estimating total amounts of unwarranted use, e.g., trash, vandalism, unleashed dogs.

  Sampling and estimating magnitudes of indicators of environmental degradation, e.g., trail erosion, disturbance of nesting birds, vectoring of invasive plants.

6.2.1.4 Promotion and recruitment

- **Goal**: Use the Crum Woods as an asset to attract top students.

- **Management actions**:

  Highlight the Crum Woods as part of the educational facilities to prospective students.

- **Measures of success**:

  Periodic survey of new students to determine the influence of the Crum Woods on their acceptance decision.

6.2.2 Ecosystem function priorities

6.2.2.1 Crum Creek and tributary streams

- **Goal**: Manage the Crum Woods to improve the water quality in Crum Creek and its tributaries.

- **Management actions**:

  Augment and maintain forested riparian buffers.

  Reduce stormwater runoff from campus buildings, roads and trails.

- **Measures of success**:

  Monitoring water quality near where streams enter and exit College property (environmental engineering curriculum projects).

  Periodic sampling of aquatic species composition near where streams enter and exit College property (potential biology curriculum projects).

6.2.2.2 Healthy plant communities and wildlife habitats

- **Goal**: Protect and enhance native plant communities to provide quality habitat for wildlife.

- **Management actions**:

  Maintain deer density at appropriate levels through lethal removal.

  Control invasive plant species.

  Establish secure, long-term protection of Natural Areas and remaining amount of forest interior.

  Convert and maintain turf areas in Crum Meadow, Crumwald Farm and pipeline rights-of-way to meadows dominated by native herbaceous plant species.

- **Measures of success**:

  Annual assessment of deer browsing impact, using U.S. Forest Service's deer impact index (potential biology curriculum project).

Annual sample of plant species composition and diversity in Natural Areas and meadows (potential biology curriculum projects).

Photo-documentation of vegetation changes at fixed points.

Periodic mapping, using global positioning system, of the extent of the most severely invasive plant species (potential biology curriculum project).

Periodic mapping, using remote sensing, of the extent of contiguous forestland.

Periodic sampling of migratory and breeding bird species utilizing the Woods and adjoining meadows (potential biology curriculum projects).

Periodic sampling of other animal species groups utilizing the Woods, e.g., turtles, small mammals, amphibians, snakes, butterflies (potential biology curriculum projects).

6.2.3 Implementation of A.R.M. monitoring program

Coordination of a Crum Woods adaptive resource management program would logically be the responsibility of the Woods manager under the guidance of the Woods supervisor. Other faculty with curricular or research interests in participating would also be strongly involved in A.R.M. planning and decision-making.

Designs and protocols for monitoring projects would have varying degrees of rigor depending on each project's objective. In some cases, it will be desirable to follow strict rules of scientific experimental design to make it possible to conduct valid statistical analyses of the data. In others, a less formal approach will be adequate.

Detailed monitoring plans are beyond the scope of this report. There are many sources of further information that will be useful in conceptualizing, designing and implementing various components of an adaptive resource management program, including monitoring projects. Examples include:

- **Selected papers in scientific journals**

  Grumbine, R. E. 1994. What is ecosystem management? *Conservation Biology* **8**: 27-38.

  Nielsen, C. K., W. F. Porter and H. B. Underwood. 1997. An adaptive management approach to controlling suburban deer. *Wildlife Society Bulletin* **25**: 470-477.

  Walters, C. J. and R. Hilborn. 1978. Ecological optimization and adaptive management. *Annual Review of Ecology and Systematics* **9**: 157-188.

- **Books**

Elzinga, Caryl L., Daniel W. Salzer, John W. Willoughby, James P. Gibbs (eds.). 2001. *Monitoring Plant and Animal Populations*. Blackwell Science, Inc., Oxford, U.K. 368 pp.

Feinsinger, Peter. 2001. *Designing Field Studies for Biodiversity Conservation: The Nature Conservancy*. Island Press, Washington, D.C. 219 pp.

Gunderson, Lance, C. S. Holling and Stephen S. Light (eds.). 1995. *Barriers and Bridges to Renewal of Ecosystems and Institutions*. Columbia University Press, New York. 593 pp.

Hee, Shane Que (ed.). 1993. *Biological Monitoring: an Introduction*. John Wiley and Sons, New York. 672 pp.

Heyer, W. Ronald, Maureen Donnelly, Ronald W. Heyer, David Wake and Roy W. McDiarmid (eds.). 1994. *Measuring and Monitoring Biodiversity: Standard Methods for Amphibians (Biological Diversity Handbook)*. Smithsonian Institution Press, Washington, D.C. 384 pp.

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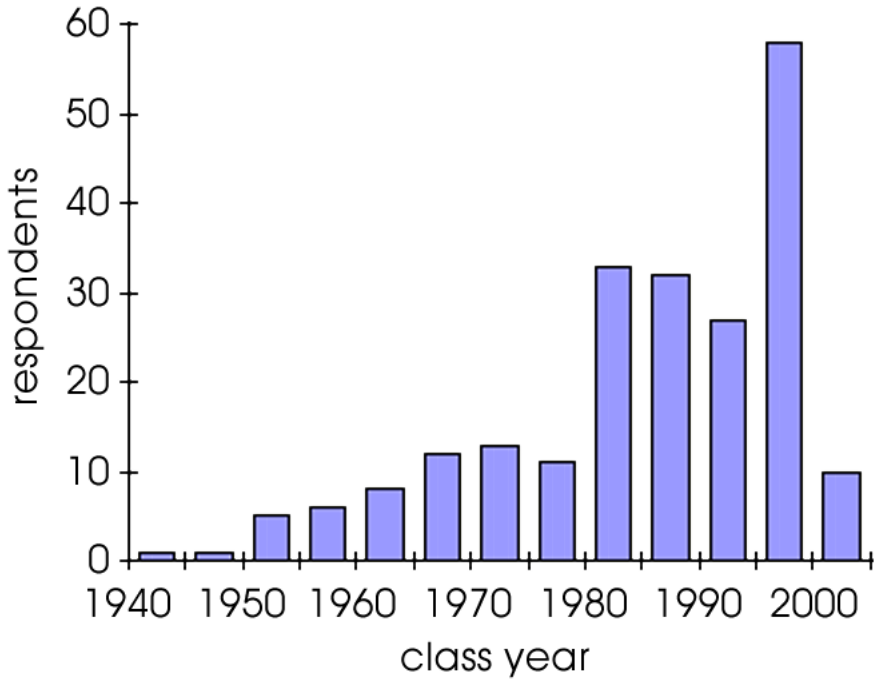
Appendix A. Summary of Alumni Survey Results

The alumni survey was conducted by questionnaire, posted as an interactive web page on the College's web server. The Alumni Relations Office sent out a request by e-mail with a link to the questionnaire on 18 May 2002 to those alumni living in metropolitan Philadelphia whose e-mail addresses are on file, numbering approximately 1,320 people (G. Semenuk, pers. comm.). Roger Latham distributed a similar request by e-mail to 120 other alumni who live farther away. The response rate was 16% of the number of initial recipients (224 respondents). Summaries and excerpts from responses to each of the questionnaire items (boldface) are presented below.

What is your class year?

Fig. A1. Class year of alumni survey respondents.



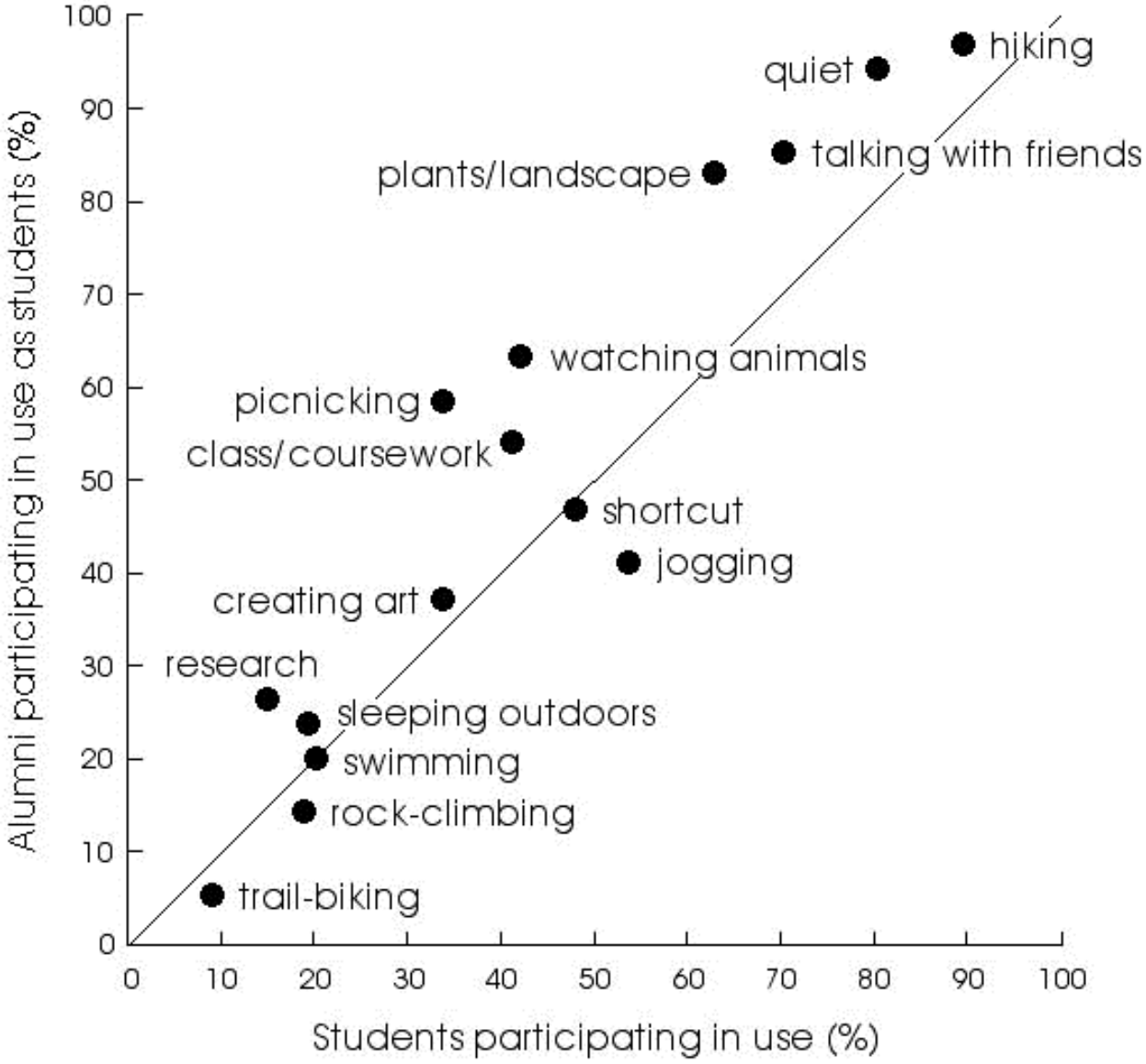
As a student, how did you use the Crum Woods, including Crum Creek and Crum Meadow? Please rank all that apply, either 3 (>10 times in a typical semester), 2 (2-10 times in a typical semester), 1 (once or twice a year), or 0 (never).

Table A1. Alumni uses and frequencies of use of the Crum Woods when they were students.

responses provided on questionnaire	mean use level	% whose use level = 0	1	2	3
Hiking or walking the trails	2.45	3.1	5.4	34.8	56.7
Sitting and enjoying the quiet	2.21	5.8	13.8	33.5	46.9
Viewing the plants and landscape	1.90	17.0	14.7	29.9	38.4
Talking with friends	1.81	14.7	19.6	35.3	30.4
Watching birds or other wildlife	1.36	36.6	15.6	23.2	24.6
Jogging or cross-country training on the trails	0.98	58.9	7.6	10.3	23.2
Picnicking	0.93	41.5	29.9	22.8	5.8
Course work	0.92	46.0	25.0	20.5	8.5
Passing through from campus to residence, Pendle Hill, or other destination	0.90	53.1	15.2	20.1	11.6
Sketching, painting, photographing, or creating other art	0.65	62.9	16.5	12.9	7.6
Research	0.45	73.7	12.9	8.0	5.4
Sleeping outdoors	0.32	76.3	16.5	5.8	1.3
Swimming	0.30	79.9	12.1	6.3	1.8
Rock climbing	0.21	85.7	8.9	3.6	1.8
Riding a trail bike	0.09	94.6	2.7	1.8	0.9
write-in responses		% reporting use			
Dating, romance, sex		4.9			
Ice skating		3.6			
Meditation		3.1			
Crum Regatta		2.7			
Playing games or exploring with friends		2.7			
Sledding, “traying”		2.2			
Bonfires		1.8			
Escaping pressures, “preserving sanity”		1.8			

(Several other responses were received, each accounting for < 1.5% of respondents.)

Figure A2. Comparison of Crum Woods uses reported by alumni and students. The diagonal line has slope = 1; dots above this line represent uses reported at a higher rate by alumni than by current students and dots below the line, the reverse. Percentages plotted for alumni are the sums of nonzero values from each line in Table A1. For details on student data, see Appendix C.



Did you go into the Crum Woods during any class(es)? If so, in which one(s)? Did you go into the Crum Woods outside class time as part of any assignment? If so, for what class(es)?

45.5% of respondents reported taking courses that used the Woods during class time. 36.6% reported spending time in the Woods on class assignments.

Table A2. Subjects of alumni-reported classes that used the Crum Woods and Crum Creek.

decade	subject matter of classes using the Woods
1950s	field zoology, hydrology, surveying, systematic botany
1960s and 1970s (nearly identical)	animal behavior, ecology, introductory biology, invertebrate zoology, mechanics, mycology, physics, plant physiology, systematic botany
1980s	animal behavior, anthropology, dance choreography, drawing, ecology, environmental engineering, introductory biology, invertebrate zoology, painting, photography, physics, plant ecology, systematic botany
1990s	animal behavior, biodiversity seminar, biomechanics, drawing, ecology, environmental education, field ornithology, introductory biology, introductory studio arts, invertebrate zoology, music, painting, plant ecology, religion, sociology, theatre, systematic botany

How do you believe the uses of the Crum Woods should be prioritized? Please type before every item, either H (high), M (medium), L (low), or Z (zero priority).

Table A3. Alumni priorities for Crum Woods use.

	Mean priority level	% whose priority level =			
		Z (0)	L (1)	M (2)	H (3)
Aesthetic enjoyment	2.88	0.9	0.4	8.9	89.7
Maintaining the Woods' contribution to the environmental quality of the area (flood and erosion control, soil development, nutrient assimilation, local climate regulation, wildlife habitat)	2.85	0.9	0.9	10.7	87.5
Protecting rare species and intact ecological communities	2.66	1.8	3.1	22.8	72.3
Non-mechanized recreation (hiking, cross-country training, rock climbing, etc.)	2.48	1.8	6.3	34.4	57.6
Spiritual reflection or meditation	2.45	3.1	7.1	31.3	58.5
Teaching/learning	2.41	3.6	5.4	37.9	53.1
Opportunities for volunteer community service (trash cleanup, trail maintenance, invasive plant removal, forest restoration planting, scientific monitoring)	2.26	3.1	8.5	47.3	41.1
Scientific research	2.15	3.1	11.6	52.7	32.6
Incorporation into the curriculum	2.06	7.1	12.5	47.3	33.0
Restoring the vegetation and wildlife to an approximation of their character before European settlement	1.57	15.2	33.9	29.5	21.4

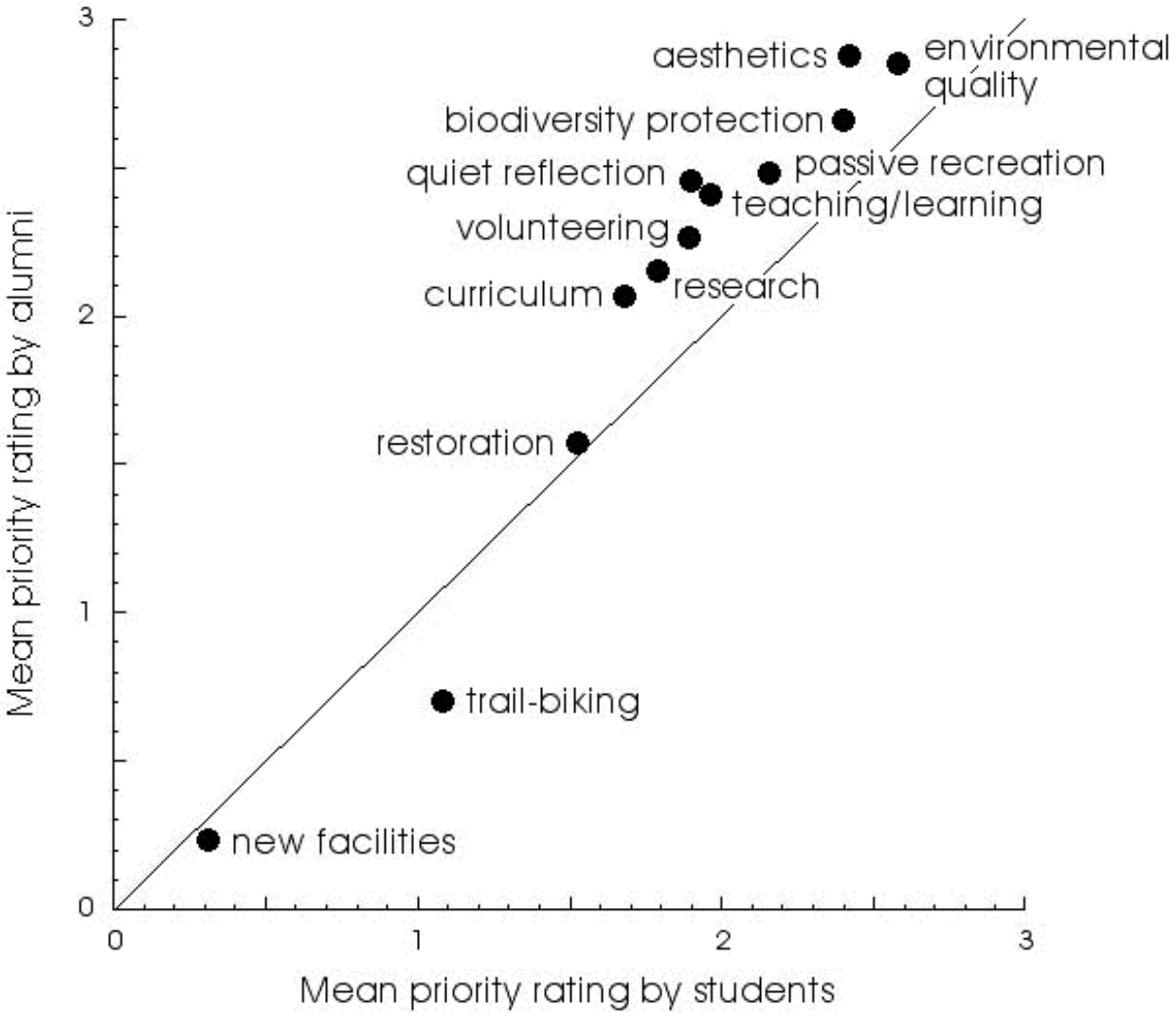
(table continued on next page)

Table A3 (continued)

Dog walking	1.05	29.9	39.7	25.9	4.5
Trail biking	0.70	43.8	44.6	9.4	2.2
Development, when land is needed to build new college facilities	0.23	81.3	15.6	2.2	0.9

(Several other responses were received, each accounting for < 1.5% of respondents.)

Figure A3. Comparison of Crum Woods land-use priorities assigned by alumni and students. Scores plotted for students are the raw scores (which ranged from 0 to 4) multiplied by 0.75 to match the scale of the alumni scores. For details on student data, see Appendix C. Dog walking was not included on the student questionnaire.



In your opinion, which two or three uses of the Crum Woods should be given the highest priority?

A programming error caused a failure to record responses to this question.

What stands out in your memory about how faculty, students, or other members of the community were making use of the Crum Woods when you were a student?

Representative sample of answers (class year is in parentheses):

It was a "different" place, a place to get away. When you met a professor walking in Crum you tended to talk about things other than class, when you met someone from the Ville, it was a more relaxed conversation. ('58)

The mouse-population study, one of the most enjoyable, memorable things from a great four years, along with a fish-netting slog in the creek, (for identification only, I think). Also, and really most memorable in terms of length of time, all the walks, enjoying the trees and blooming things, and wind, and seeing the water, etc. ('63)

Most use was passive, but the Crum Woods was bigger then, and traffic noise was almost nil, pre-highway. I remember the rallies against the "Blue Route," all to no avail. I know I needed to get away from other people there, just to hike or sit and watch the sky occasionally. Probably not safe, in retrospect, but it certainly felt good at the time. ('64)

Bob Enders collected firewood there for the fires that warmed us at the Sunday teas. In Bio 1, 2, we had a lab each semester with a walk in the Crum. I remember standing in awe of ferns and *Equisetum* that had a history back to the coal swamps and Pennsylvanian age. Bill Denison and Luzern Livingston would collect plants in the Crum and the plants were still fresh during lab. ('66)

We used it a lot, but seldom ran into each other there. I remember my art history professor, Dr. Walker, walking away from the podium one day and exposing his rolled-up trousers and bare feet (with shirt and tie). He explained that he walked to the lecture hall by taking a path through the woods and that morning he had to wade to cross the creek because the water was over his stones. I often ducked into the woods to take a break from studying. I studied in Martin Library, although I was not a biology major, partly because it was close to the woods and trails. I grew up in Michigan, not in a big city, and spent the summer before college as a camp counselor. I was not used to the big city environment of the Phila. area, and needed the solace of the woods. I wanted to know when the May-apples started blooming, and to smell them, to find the first skunk-cabbage in the low places, the witch-hazel in early spring (it also smells good). ('69)

A most memorable time in my entire life: Ice skating on the Crum by moonlight, first (freshman) year. I had never seen natural ice outside, before. Bonding with student-friends at the same time. A few faculty and students showed me where to walk and what to look for, appreciating what grew there. Very special shared appreciation, as I had never seen Eastern plants before. Most of all: The more-wild place is QUALITATIVELY different from anywhere else on or near campus. The Crum gave an emotional-spiritual place for respite and a special "community" and personal support only natural places can give. I grew up in a city & had found a vacant lot for the same purpose, there. To me, it's important. … ('71)

It was a place for reflection and renewal. It's where we went when we wanted a quiet, wholesome good time, or wanted to make an important decision. I can remember several

friends who went to the Crum to give up smoking — and did — and many campus poets, including me, went there to write. … ('72)

A friend watching the spring warblers migrate and trying to help me learn them way up in that canopy. Professors, other students and I used the Crum as a small, preserved piece of the natural world, however altered and degraded, in which to discover the diversity of life. There is no substitute for the epiphanies that occur as we explore nature while we are learning about organisms in class. I didn't have a car most of the time that I was at Swarthmore — the Crum was my outdoor classroom. ('73)

I remember how many uses it was put to: cross-country training, art courses, science courses, horticultural collections, socializing (including bonfires), walking. My father, also a Swarthmore alumnus, ice skated to class on the creek from Mary Lyons one winter! (An unusual winter, I'm sure.) ('80)

People found it refreshing to walk through the woods. The woods were a spiritual, as well as an ecological, detoxifier. ('80)

It was a meeting place, a place of peace and refuge, a place to get exercise and enjoy nature. ('81)

Swarthmore is an intense place, and the woods gave us a place to decompress, to enjoy a quiet, serene place, away from the hustle and bustle of the school and Delaware County. For me and my fellow students, it was invaluable psychologically. ('81)

A nice diversionary get-away place for students to pull themselves out of the stresses of their daily life and realize there were other, more important things in the world around them. ('82)

We took nature hikes. Took a break from studies. Contemplated theories, composed music and drew pictures (there's nothing that spurs creativity more than a walk in the woods). Swam in the Crum (I hear it's now too polluted to do that??!!). Strolled with professors. Gazed at the stars. ('83)

It was a place to get away and unwind. It was much less cultivated and controlled. It was a place where art was created and discovered. It was a place to deepen friendships. It was an essential counterbalance to the intellectual intensity of the campus. ('85)

It was an amazing place that was physically so close to campus but experientially very far away/refreshing. ('85)

It was just a wonderful resource to have to be able to "get into nature a bit". However, I stopped going there very much after I was chased by a naked man on one of the trails when I was jogging (I got away). So safety might be something to think about, although you certainly can't make a woods completely safe. ('86)

The Crum was certainly important for me as a place to go to get away from my day to day activities and concerns and reflect. I know that many others viewed the Crum Woods similarly. One of the things that drew me to Swarthmore was the peacefulness and beauty of the campus; the Crum Woods certainly have a lot to do with creating that atmosphere. ('86)

It was constantly underutilized by all members of the community, meaning I never encountered many there. I don't think that's necessarily a bad thing for the woods, just for the students. ('88)

Many of us, including myself used it as a place to get away with friends, or to simply walk by ourselves and collect our thoughts. Some of the most important things that happened to me at Swarthmore happened in those woods. We also slept out there a lot. ('88)

To, like Ansel Adams, have "within the grasp of consciousness a transcendental experience." ('88)

Volunteer cleanups as a way to bring people together ('88)

Well, there *was* the Naked Petronella Society, but you'd probably rather not hear about *that*. In general, the woods meant privacy. You could go there to be alone, or to have a tete-a-tete, without constantly running into people the way you do on campus. It's the right environment for big emotional scenes. ('88)

Creativity and exploration were stimulated by the Crum. Everyone speaks fondly of their time in the Crum, from the amphitheater to the pine forest sacrificed to the Blue Route. ('89)

Swarthmore's rigor put intense pressure on many of us. The Crum was the living, breathing antidote, a primeval haven where we found refuge from the confines of books and papers, and could get back to the basics of what life is made of: ecstatically moving our bodies to move through the land, guided by our feasting senses. ('90)

The Crum to me was a place of peaceful quiet magic. My fondest memories of it are of sitting still in the amphitheatre, appreciating the stillness as a break from the bustle of daily life; of being taken to the mysterious ruins my freshman year; of hearing, and being told about, a couple of owls that lived there; of walking down sunlight-dappled paths with friends to the creek; of one magical Alumni Weekend when a couple of us went down to the mist-shrouded meadow at 2 a.m. and saw a vast swarm of fireflies swirling in a helical column around a tree. And of the night I went walking there shortly after the anniversary of my mother's death … ('90)

I was surprised that sex was not on the list of "how did you use the Crum Woods when you were a student." I recall that, and I think naked folk dancing (naked Petronella, a Scottish dance with a lot of bouncing up and down). I liked to walk on the trails, and it was a good date, and I remember sitting in the daffodils in the spring with my date, watching other people with their dates pass by (not noticing us), in the moonlight. ('92)

What stands out in my memory is how many different ways different people made use of the Crum. It was an easy place for people to go and feel like they had left campus — with all of its stresses — behind. Walking through to ML, or popping out in the Wistar garden, sitting and watching the fireflies, sleeping under the hollies, going there to have a serious talk with a friend...that doesn't even begin to describe what that place encompassed. Freshman year, the Crum was the place to go when my roommate needed our room to herself. I even cajoled my cat into walking through the Crum with me a few times. ('92)

As a refuge from the pressures of classes, and as a place to have fun (e.g., picnicking, the Crum Regatta, taking photographs). I never felt as if the College were actively promoting the Crum Woods, but letting students discover it on their own, for those who wanted to explore. ('93)

Many folks I knew used it on occasion. I was always shocked to meet someone who didn't. Several used it for exercise or meditation. Most used it as a place to walk or sit with friends. ('93)

The ability to walk peacefully through the Crum is one of the greatest rarities at the college, allowing for true reflection and perspective — two rare things in colleges these days. ('93)

Creative uses, such as the Shakespeare in the Crum day, where scenes from Shakespeare plays were performed in various appropriate parts of the Crum (e.g., Caliban emerging from the creek). ('94)

There were traditional games played there; capture the flag. I also remember walking through the Crum with fellow students at night after a nice snowfall, one of my favorite Swarthmore memories. In Biology II, we examined different square meter patches of the Crum for biodiversity — very cool. ('94)

Walking, walking, walking, shortcut to ML, sleep-outs, birdwalks, plant walks, star/meteor watching, occasional gatherings (for singing, campfires at the henge, rituals, thunderstorm celebrations), water watching, Crum cleanups, the Regatta, and lots of walking. ('94)

The Crum Regatta, sledding, skinny dipping, walking, regaining sanity. ('95)

The Crum was always the place to get away for a bit of peace and quiet; a nice morning walk, a chance to see wildlife and trees, a place to stay connected to the world of nature in the increasingly artificial surroundings of suburban life. There was always something new and something old in the Crum. ('95)

The joy and comfort that the Crum brings the community, whether for bagpiping or graduating. I also fondly recall congregating in the woods for a rainy Council of All Beings, a Navajo language conference bonfire, and sunny Crum Regattas. ('95)

Having the woods there changes the entire campus, whether you go there every day or not, so it's hard to define "use." It was an outlet for students in a sometimes stressful school, and it was good just to know it was there. ('98)

I did all kinds of research there for my biology classes, preparing me for my post-college jobs in field research. It struck me as a bit overused and unnatural (a curse upon the Blue Route!), but also as a fun and safe playground for the student body. I remember lots of melodramatic, hormonally-charged, all-night conversations in the moonlight. It was mostly a scenic place to unwind, and I think most everyone was incredibly fond of it. ('98)

I felt like the Crum Woods were a really wonderful place to get away — it is easy to feel very alone there — either alone or with a friend — which can be so important in such a small, close community atmosphere like Swarthmore. ('98)

I thought it was used well as a shared resource. Never really felt too crowded. As a 2nd-year, we camped down in the Crum once a week as part of the Outdoors Club. That was great, to get away from the closed-in campus life for one night a week. It was also awesome to go down there for events — drumming gatherings, other... Or to walk down there to talk with a friend. ('98)

It wasn't just the biology students who could be found in the Crum. From students traversing the Crum as a short (long) cut to class to neighbors jogging to engineers scaling the trestle, the woods invited all. To the casual observer they are a peaceful respite, despite the hum of the Blue Route. As I learned more about the environment, I realized the treasures to be found there. I saw my first trillium on a hill across the creek, was surprised several times by a resident blue heron winging above the water, and began to appreciate just how diverse these urban woods are. ('98)

The Crum was a wonderful place to escape from the regular life of Swarthmore, where I could go to remember that there was more to life than the problem sets sitting on my desk. Every time I took a walk in the woods, I would wonder why I didn't do it more often. I was really glad when my drawing class gave me an excuse to frequent the Crum often and to sit and observe and draw for hours. ('98)

The Crum Woods played a huge role in my time at Swarthmore. I spent several hours a week there: jogging, walking, talking with friends. My experiences there as a student in an introductory ecology course helped inspire me to pursue ecological science as a career. As a graduate student, I have taught an introductory ecology course on a campus with little native vegetation left, and have found it difficult to inspire my students the way I was inspired at Swarthmore. ('98)

It was a great place to go for all students for some peace away from the hectic pace of Swarthmore. Also, a wonderful outdoor laboratory and a contrast to the stylized beauty of the arboretum. ('99)

People from all aspects of Swat community used the Crum — I saw professors as well as students engaged in both recreation and research. Could have been used even more often in curriculum. ('99)

Some of my best classes were the ones where I spent a lot of time in the Crum. I think the Crum helped a lot of people maintain their mental health in such an intense atmosphere. ('99)

The Crum Woods were a refuge, a place to go in times of great stress and sorrow or great joy, a place to be alone with nature and gain perspective, a place to get away from physical noise and also seek inner quiet. ('99)

I really enjoyed it being incorporated into various classes — looking at invertebrates in Bio 2 with Rachel Merz, identifying trees in Ecology, etc. Being a part of the Monitoring Project — keeping track of stream health. Also, groups of my friends would get together to go for walks in the Crum — either to learn more about the woods from others in the group, or to clean up trash along the paths. The Crum was also an escape for me — when classes and life got too stressful, a nice long walk by myself in the Crum helped me to put everything in perspective. It was essential to my mental and emotional health. ('00)

I went walking in the Crum was a phrase that meant, "I took time out for myself to be away from the Swat neuroses." ('00)

In my experience, most people used the Crum for 1) individual retreat/reflection and 2) walking/running. The Crum is also a good place for class instruction or group discussion, and some of this occurred, though there could be more. The essential quality of the Crum for the Swarthmore community, in my opinion, is its value as an escape from the hectic daily pace. While group work in the Crum should be encouraged, nothing should compromise the Crum's ability to offer solitude. As the College develops further, the need for this "undeveloped" space increases, rather than decreasing — it is the campus's complement, the yin to its yang. ('00)

It was a place for my friends and I to go and have in-depth conversations and to enjoy the "real outdoors" compared to the very manicured arboretum. ('00)

Relaxation, walking, jogging, dog-walking, & classes studying various plant and animal species were all common activities during my time as a student. I feel that all of these activities are appropriate. I sincerely hope the Crum Woods can be preserved in their entirety, and not fall victim to land constraints, or greedy desires to "develop" the land. The Crum is one of the truly impressive features of Swarthmore's campus, and needs to be preserved in its entirety to retain its beauty and significance. ('00)

There were always people in the Crum, walking, running, studying, thinking, sitting, doing research. On any given day you would be as likely to find students in hip-high waders catching bugs in the middle of the creek than to come across someone painting a watercolor. Many of the

biology classes that I took involved fieldwork in the Crum, and other non-biology professors sometimes held class in the Crum on nice fall or spring days. ('00)

Aside from some research in a few classes, I remember that the Crum was mostly a recreational site. I had many friends that would go there to work on art projects, to journal, camp out, go swimming, picnic, etc. I know of many people as well who would go to the woods just to clear their heads when they were stressed and to be able to think clearly and sort out whatever troubles were on their minds. I know that within my close group of friends many of us were very interested in the plants that had been pointed out to us on Bio 2 walks and frequently went back to try to relocate them and find more. There are also the ruins of an old garden where several of us would go picnic. ('01)

I was struck by how many people used the woods for reflection or quiet talks with friends. During my many runs in the woods, I encountered many other students, college staff and community members who used the woods for recreation. I think it's an extremely important resource not only for the college but also for the community. In fact, the community's access to the woods might even help foster good college/borough relations, since Swat's campus seems fairly removed from the rest of the community. I was also impressed by how many different academic disciplines used the woods in coursework — art, biology, engineering, chemistry. ('01)

It was there if you wanted to go, but not a necessary part of life; sort of a nifty little secret for those in the know. ('01)

They nearly always came out calmer and more focussed than when they went in, whether they were walking, running, absorbing (meditating) or studying. The intellectual and psychological value cannot be underestimated. I saved the College (tens of?) thousands of dollars in psychological services by going to the Crum instead of the counseling center. I was not averse to seeking professional help (my father was a guidance counselor). I simply found that I was able to work through things by slowing myself down. The Crum was essential to this process. In some cases, it simply provided the buffer/backdrop for the amphitheater. (No class year given.)

What are your thoughts on whether the College was taking care of the Crum Woods appropriately when you were a student?

Table A4. Categories of alumni responses concerning Crum Woods care by the College.

%	category of response
26.2	about right; adequate; excellent; fairly well; fine; good; good job; no complaints; O.K.; pretty well; reasonable job; well kept; well taken care of
20.9	didn't think about it; unaware of any care by the College; didn't know
18.3	Respondent gave mixed reviews, i.e., words of praise together with complaints, reservations or qualifications.
14.1	benign neglect; took care of it by leaving it alone
11.0	Respondent expressed major complaints.
5.8	Respondent gave no response about care, but commented that Woods appeared to be in good shape.
3.7	Response was about something other than care.

What else would you like us to consider, pertaining to the use and stewardship of the Crum Woods?

Off limits to new construction. Water quality. Trail maintenance for hikers. ('50)

Prevent environmental prostitution. ('54)

NO athletic facilities! Keep them on the upper, higher ground and no large structures. ('57)

Please don't use this tranquil resource for playing fields or for more buildings — open space is a precious commodity. More use for all-college community-building events. ('57)

In this increasingly complex, regulated world, let this place remain a natural place with as little sign of man's presence as possible. ('58)

It is a joy to sit by the creek, see the water flowing over the rocks, and look deep down at the reflections and up at the treetops. A place for quiet reflection is important amidst the pressure at Swarthmore. ('58)

More student activities to introduce new students to the appreciation of nature. This is new territory for many people! ('58)

The primary danger facing the Crum now involves the College's potential placement of athletic fields on the plateau across from the Strath Haven condos. Such placement would be engendered by the taking of land near the station for the new Inn, meaning that the softball field would need to be relocated. While I am a supporter of the Inn, I am hopeful that sufficient practice space could be found within the remaining field space. With football's demise, the softball field is not needed for practice in the fall. So the issue is where to play softball after the Inn is built and the roads relocated. Not an easy problem to solve, but one not worth losing the Crum plateau for. Not to mention creating the problem of where to compost the town's leaves. I am delighted to see this survey … and would let you and others know that there will be a firestorm of opposition to the College if they seek to put the practice fields on Crum territory. It will make the football controversy look like a petty argument, and I will be among the leaders of the movement to "Save the Crum." ('61)

No logging. Control bad erosion. Clean debris from the stream. ('62)

Maintain it with loving care, keeping out all development. ('63)

Please don't let it go for ball fields or parking lots! ('63)

I just want to reiterate its importance as a sanctuary — for flora and fauna, for people. I believe it's very important to maintain and improve it as a natural area. ('64)

Incorporation into more biology and chemistry classes — maybe you do that already. Would it be possible to try to enhance the diversity of native species and remove some exotics, without offending the horticulture foundation? ('64)

I did think it was too bad that [the] interstate had to come so close (I don't know what the impact of that was noise-wise since I haven't been back). Come to think of it, if noise from nearby highway(s) is a problem, perhaps some sort of noise abatement might be considered, such as planting a thick buffer of evergreen trees. ('66)

I now live in Swarthmore and am troubled by the infringements on the edge of the woods by the College and associated water runoff and erosion. In that connection, it should be remembered that the Crum Woods are a major (though underused) amenity for residents of Swarthmore, as well as students. Also think the emphasis on native species is fundamentally

fallacious and often overdone. The criteria should be aesthetic, compatibility with other plants and uses, etc., not a misguided quest to restore an original state that must always have been dynamic and changing. ('66)

Maintain that cacophony of birdsong that arises each spring! What about work on the water quality and sediment contamination in Crum Creek. Some neat environmental project there along with surveys of fish and eels. Not too sure how you can get back to pre-European vegetation in the current state of climate nor should you. ('66)

The Crum should be used for promotion of the educational mission of the College. There are many other facilities (national wildlife refuges, state and federal parks and private estates) which seem more appropriate for other purposes. While the use of our resources for the restoration of the Crum to a pre-European character might seem intellectually appealing, it seems expensive, futile and counter-productive to me in what is now, after all, a suburban environment. ('66)

I live near the college and walk through the woods and campus frequently. While it appears that not many students take advantage of the woods, it adds a quality that becomes an important part of the Swarthmore experience. Its presence increases students' respect for the environment. ('68)

Have used/visited Woods occasionally, since graduating. ('69)

Keep it as natural as possible. ('70)

Take care of it (actually, I would guess that you will) and make sure that the aesthetic and spiritual nature of the place is preserved, no matter what else people may use it for. Don't build there. ('70)

Please do not chip away at the integrity of the Crum Woods any more. Also, the value cannot be measured only by how often a person goes there. We also carry an awareness that the woods are there, with inhabitants and beauty, on the days we are not visiting there. ('71)

Although it is heavily used, some things (bikes) should not be allowed. ('72)

I feel that it was an important part of what made Swarthmore a special place for me, so I would hope that the college would do what it could to preserve it. ('72)

Nobody ever likes to hear that part of the solution is money, but it is. Someone needs to take an active role in restoring areas that are eroded and trampled; controlling exotics if they are a problem (and if they're controllable — this step requires triage); controlling use particularly during weekends by patrolling if necessary; maybe zoning the area so that some portions are protected for research and teaching, some areas are closed completely, some areas are no dog zones and some are o.k. for dogs; start a public environmental education program — this means there is a college presence and you can explain to people what their dogs are destroying. I could go on and on. This is what I do for a living — I manage university lands (not usually so conveniently located as the Crum!) that are used for conservation, teaching, research and public outreach. If you would like help with a management plan when the College has decided what to do (or better yet, listen to my suggestions beforehand on what to do), I would be glad to help. Unless, of course, the idea is to use the woods for buildings — there's plenty of other space for that. ('73)

It should be deeded in perpetuity never to be developed (deed-restricted). It should be maintained in a well planned and well-organized fashion to promote erosion control and plantings. ('75)

I am horrified by the constant lessening of natural and cultivated green space in the area and think the college should be a conscious model for others in this regard. ('77)

It was a sacred place, a place simultaneously "apart from" yet under the umbrella of the college; apart from the sometimes too competitive, too worldly part of the college; a necessary corrective. ('78)

Responsible long term stewardship and NO REDUCTION IN SIZE! ('78)

Increase student interaction with the woods through lectures and field study. Consider developing a planned nature walk with some information placards at regular intervals. Use sound ecological and horticultural principles for any planned changes. Restoration to pre-European habitat may be impossible and is anyway highly questionable. Restrict access to all motorized recreation, ideally this would include trail bikes as well. ('79)

As long as trash is kept out of it, I think it should be left be. ('80)

I just want to talk about how much Crum Woods meant to me both while I was in college and later. While at Swarthmore, it was the place where I discovered mountain-laurel, skunk-cabbage, may-apples, jack-in-the-pulpit (I came from the Southwest and had never seen these plants). I used it as an escape from people and the pressures of Swarthmore. After I graduated I continued to live in the area — but closer to Philadelphia in a neighborhood which was, to say the least, not very green or attractive — and I went walking in the woods several times a year. One of the reasons I think it is important to incorporate the woods into the curriculum is because I came to appreciate the biodiversity and delicate balance of the area through that class. And in my drawing class I learned to look at the woods. Continuing to build an appreciation for the area will be important to future efforts to sustain it, and I think that courses are one good way of doing so. ('80)

I am very concerned about the college's ideas of putting fields in the Crum or using that area for expansion. At a time when the entire country is talking about the importance of open space, and the benefits it brings, it seems ironic that such an enlightened institution would be devouring its open space, especially considering the paucity of open space in Delaware County. The Crum needs to be protected, and this should be given the highest priority by the school. ('81)

I never felt unsafe there, but don't know how people feel these days. I would want anyone who wanted to go there at any time to feel safe and be able to call for help if the need should arise. ('81)

Causeways on trails through areas that become swampy after rains, etc. ('82)

Work with the CRC watershed group. Make sure the Crum Creek woods and their management are part of the overall land use plan for the college. Consider upstream and downstream impacts. ('82)

Good opportunity for students to study environmental science. ('83)

I am a dedicated alum who is a career biologist and educator — it is absolutely essential that the college act as a responsible steward of this wonderful natural area. I hold the college in high esteem and respect, but any effort to develop this area would be a crime. I was quite concerned when I read in the latest alumni bulletin that the long range planning committee "recommended" the Crum plateau as a possible area for future expansion/relocation of athletic facilities and am glad to have the opportunity to speak AGAINST such use. ('83)

Leave it! Treasure it! Allow it to enrich the "education" of all in the college community. In our modern age we need to keep our connection to nature more than ever. Nature is a necessary part of every complete education and is in the best Quaker tradition of our school. ('83)

Stress that such places of open space so near the city are even more rare now than when I was a student. The Blue Route ate some of it (both college-owned and not). Don't give up more to development. It is a unique place for quiet reflection (despite the background din of the Blue Route). Keep it quiet (no dogs, bikes, etc.). ('83)

The Crum represents an aspect of connection to the natural plane of creation that underlies the arts and sciences we strive to understand through study. Having such a wonderful backdrop to the campus affords it a dignified, peaceful sanctuary for flora, fauna as well as reflection for the mind and spirit. May we continue to commit ourselves to the preservation of the Crum whose immense intangible value is only rivaled by its irreplaceablility. If expansion be such a priority, let investments be made into the community to take up contiguous housing that can be later converted to whatever needs dictate in the future. Although the initial cost may appear to be high, [ignoring] the cost of losing such an asset is very short-sighted. Over and over throughout our cities and nation, we all enjoy access to parks and preserves which improve the quality of life for all. In the case of Swarthmore, I believe the Crum will also allow and encourage the freedom of thought that we value so much. ('83)

The Crum Woods are a wonderful resource, but I think that the National Parks phrase of "multiple use" can create problems of overuse. Bikes are particularly destructive to paths, and should not be allowed unless there's a paved surface. Perhaps some broader education to everyone about restoration practices? Could have Crum Days to root out invasives? I'm glad that there is now some active management of the fate of Crum Woods and it can serve as a case study of community involvement and restoration ecology. ('83)

The woods are a beautiful and valuable resource to the College and community at large. They should be preserved, maintained and protected from development and other destructive forces. ('83)

Wonderful place for students, faculty and staff to unwind a bit and feel more "centered" within. ('83)

Do not use it for development. ('84)

Preserve it preserve it preserve it. Protect it protect it protect it. ('84)

Better to build upwards, if necessary, than to use new land. ('85)

Don't let them develop it. Don't let it get overrun with people, for whatever purpose. ('85)

I don't really like the stones in Crum Meadow. A few benches are nice, but it's not at all mysterious, as I suppose it's meant to be. I think it's an eyesore. Both as a student and recently there were always times when a naked man would roam the woods, making it feel less safe. I am not a big fan of using the trails for biking. I appreciate the time and consideration being taken to care for the woods, which are such an invaluable resource. ('85)

I live in Wayne and use the Crum several times a year to take my children hiking and exploring. And by the way, were you kidding with the dog walking question? ('85)

I suppose introducing some deer predators is out — people never seem to appreciate wolves, mountain lions, etc. Of course, that's not just a problem with the Crum; once we got rid of all of our competition at the top of the food chain, we caused all sorts of problems. Oh, well. ('85)

I think my comments mostly refer to the meadow as that is what I mainly used. ('85)

I'm glad you're surveying alumni (and, I imagine the contemporary Swarthmore College community). I hope you'll open the forum on use and stewardship goals to the broader community included in the same watershed. ('85)

Just don't build there. ('86)

It's a great community resource, and compared to my time there should have more attention paid to it — academic attention would be fine, though not at the expense of its existence as a thoroughly non-academic addition to the Swarthmore environment, for use by both individuals and the community for fun, relaxation, meditation and reflection, etc. ('87)

Protect it! ('87)

Development on campus should consider protection of the woods as a priority. ('88)

I believe the Crum is a special resource that should be vigorously maintained as an ecological treasure — for careful use by people — and not be subjected to development in any way. ('88)

Please don't ban dog walking. It's a great place for families with dogs, and it doesn't seem out of control to me. I would be very sad. ('88)

Save it, but don't worry about changing it. It was perfect the way it was. ('88)

Thanks for asking. Please preserve it. It was one of the main reasons I was interested in coming to Swarthmore, actually. I found the Crum a very important part of being there. It was always a good place for a quiet walk, whether alone or not. Now that the Blue Route fight is over, I think it's especially important to preserve it. ('88)

They are a wonderful resource for both the college and the Ville (not to mention the organisms that live there). I would urge that they be kept undeveloped. ('88)

I think it is an amazing selling point for Swarthmore to be able to offer an environment that feels like the middle of nowhere that is in fact 20 minutes from Philadelphia. Truly the best of all worlds! ('89)

I'm hesitant about the pre-European aspect as a reference point of an "ideal" woods. Would we initiate periodic burns to more effectively simulate N.A. land-use practices? Instead, I'd like to see sections of the woods reflecting various use periods throughout time. In other words, a place where "invasive species" are OK, a place that resembles a burned landscape, a post-European "wild landscape" after the stopping of burning etc., etc. ('89)

The Crum Meadow seemed too unnatural mowed; natural displays of indigenous plants and collections of interesting non-native plants with attention to conservation issues before development. ('89)

I would be very sad to see the woods, in whole or in part, replaced by buildings. I think it serves various valuable services, both ecologically and to the college community. Having never taken a bio class at Swat, I don't see a particular need for making study of the Crum a greater part of the curriculum per se, but I learned a great deal there from naturalist friends, relaying what others had taught them about the flora, fauna, and habitats; I think it's a great place to teach and learn even if not as part of a formal class. ('90)

The enjoyment of Crum Woods (and Meadow) was an integral part of my Swarthmore experience. And as I live not too far away, on occasion I still visit, not only because it is a lovely space for walking and picnicking, but also for nostalgia. ('90)

Continued efforts to maintain the quality of the Crum Woods. We should always resist efforts to develop the land. ('91)

The sound from the Blue Route really degrades the experience of being out in the Crum, as I found out last year at my reunion. I guess there's not much you can do about that. ('91)

While removing some invasive species seems like a good idea, I don't that restoring a pre-1492 forest is possible or even desirable. Parts of the Crum are already more garden-like (thinking of the hillsides of naturalized daffodils) and enjoyable as such. ('91)

Consider starting a fund through alumni development for the maintenance and restoration of the Crum as an educational, ecological, and spiritual reservoir for the community. ('92)

I picked Swat over Haverford for two reasons: 1) it was a better school (natch!) 2) it was better looking, with more green open spaces. ('92)

I still use the Crum for walks and quiet reflection, and appreciate its being part of my community. ('92)

Students should continue to be able to use the woods for recreation, but not for mountain biking, since that makes it harder to maintain good trails. Or have a trail specifically for mountain bikes and other trails for hikers. ('92)

The Crum is one of the few riparian areas which we can (and should) preserve and/or restore on a large-scale basis in this community. The Crum should be a model for how we can integrate multiple functions into a "wilderness" area while preserving its essential wildness. I also think that removing exotic species should be a priority — the Crum can also serve to educate the community about the beauty of our native plant species, and the birds and animals that depend on them. ('92)

I cannot overstate the importance of retaining this resource for the college — from both ecological and student life perspectives (which don't often see eye to eye), the Crum is invaluable. ('93)

I enjoyed the Crum a number of times at night. This is one of the few places/woods in the world where I have felt safe/comfortable doing this. I think it is important to keep light pollution to a minimum and to keep lights out of the woods. ('93)

Just don't get too freaked out about students using the woods for less than adult activities. Their lives are so consumed by their studies, let them have somewhere to go where they can live an idyll. ('93)

My wish would be to manage the Woods such that … it is a healthy ecosystem, protecting the ecological communities that exist there, or should exist there. And, it would be wonderful if there could be increased active appreciation of the Woods for the community (like some kind of naturalist organization that could lead students on bird walks or botanical walks, etc...). I feel that many students didn't take the opportunity to enjoy the Crum as much as they could have, and altho' that's their decision (conscious or not), perhaps some kind of loosely organized "Crum appreciation" events (including non-science/naturalist events, but perhaps more philosophical/metaphysical, or community-oriented) would end up benefiting the community and the Crum. ('93)

Campus is fairly small, and very insular. The woods is an escape. ('94)

When I was a student, and now, both: crowding on campus was relieved by the woods. Crowding the woods cannot be relieved by the campus. The more people seek solitude in the

woods, the bigger the woods need to be. If you can't expand them, at least don't shrink them. ('94)

Its idiosyncrasies, from the daily life of the College to the American higher education experience. Without the Crum, we would find the unique refuge it offers only in the treetops. The Crum serves the College as our own Central Park Swarthmore: part watershed, part contemplative space, part adolescent romping grounds, part fishing hole, part catalog of *Ilex opaca*, all squishing between your toes in its disturbed state of grace. How does the College serve the Crum? ('95)

Please don't build on it!!! ('95)

Please try to reserve the Crum. It makes the college and its environment special. ('95)

The Crum is a VITAL part of the college environment. It is essential for the spiritual and mental well being for quite a lot of students. It must not be developed regardless of how badly the college may need space. Loss of this space would be a serious tragedy. ('95)

I didn't discover it early on, but I really appreciated the Wister garden as a place to stroll and escape. I wouldn't mind seeing more planned development of that sort. I also didn't explore and discover many corners of the Crum — perhaps more orientation effort or text could be used to encourage exploration? ('96)

I just want to reiterate my strong feeling that the Crum is the best place on campus for ecological studies and for quiet reflection outdoors. I would hate to see it get encroached upon any further than it already has. By the way, I really enjoyed the recent Bulletin article about the Crum. ('96)

Continue to provide a haven, and make sure it is accessible to all, not just students — I liked running into the occasional family or children. ('97)

I just went to my five-year reunion and looking back the Crum Woods was an essential part of my experience at Swarthmore. I think at any other campus without the same wonderful wilderness resource nearby, one would remember the friends, knowledge and experience they gained, but they wouldn't necessarily think that an appreciation of nature was something they gained from College. It also immeasurably improves the quality of life of the students, since it's a great place for fun, relaxation, and spiritual meditation. ('97)

I was pretty unaware of what sorts of care or management went into the Crum. My biggest concern was the water quality of the creek; I kept hearing that there were sewage spills into it and other contamination. ('97)

Definitely don't use the Woods for building more buildings. The Crum is just the right size and would feel like a token space if it were any smaller. ('98)

Don't develop it (for college buildings)! Work to maintain the ecosystems; involve students in this work. Keep it as a place for students and the community to celebrate life. ('98)

I would have liked a trail map. ('98)

NEVER DEVELOP IT! ('98)

No more development!! It's already too small of a natural area considering the use it gets. ('98)

Swimming! And build better trails that don't erode! The erosion is crazy in places, and in the last few years, it has completely wiped out the rare trailing arbutus that was living there. I'll have to check again next time to make sure that's true. ('98)

The beauty of the Crum is that it didn't feel managed. The trees, lovingly labeled on campus, were devoid of tags for the most part. The Crum to me is an escape, a haven, and I hope that it can be taken care of by what appears to be an invisible hand — one that tries not educate through signs deep in the hemlocks or create paths with asphalt. ('98)

The Crum Woods are a huge part of what makes Swarthmore a wonderful and special place. Magical, even. To walk a few steps away from the dorms and feel almost right away that you are in a separate place — it is easy to feel less stressed out there and more calm. ('98)

Can't think of anything else specific. ('99)

Don't build in it. At all. ('99)

Don't develop the woods; don't make it any more landscaped; do consider making it even "wilder." ('99)

I feel it is most important to strike a balance between protecting the ecological communities and environmental quality while maintaining the ability of the college community to experience the woods as a place for quiet, contemplation, and non-mechanized recreation. ('99)

I think that it is very important that the college preserve and appropriately manage the Crum Woods. As an institution committed to inspiring social responsibility and action among its students, I think that it has an obligation to model environmental awareness in its development policies. The Crum Woods are not only an important teaching resource and a natural piece of land that should be protected, but also a symbol to the students and community that Swarthmore believes that education and personal fulfillment can be gained through interaction with the natural world. By prioritizing new dorms, expanded educational buildings, or a parking lot over preservation of a part of the Crum Woods, Swarthmore would be indirectly teaching its students to devalue natural areas. I believe such a message is in opposition to the mission of Swarthmore and hope that the full symbolism of future uses of the Crum Woods is considered in long-term planning. ('99)

If dogs [continue to be] allowed, please please make the owners clean up after them. Don't let the Crum become developed for new dorms, buildings, etc. It is a great place for students and guests to visit and reflect. I think the Crum is a major reason I kept sane while attending Swarthmore as I would take long walks and enjoy the silence. ('99)

Please consider the impact of the College's choices on other institutions and people in the area, especially those whose property abuts the Crum, [e.g.,] Pendle Hill. ('99)

Please do NOT develop (in part or in whole) the woods for athletic fields, academic buildings, residence halls or the like. One of the things that makes Swarthmore unique is the size and diversity of the Crum Woods — it is a beautiful habitat almost unparalleled among liberal arts colleges in a suburban setting. It is a priceless asset of the College, and I am opposed to any effort to reduce/alter it. I see no problem with classes (e.g., Bio classes) using the woods as part of their curriculum, but I don't think that should entail them establishing a permanent presence in the woods to do so (i.e., constructing a field laboratory in the Crum). ('99)

Some attn. to Norway maple invasion, negative effects of concrete at compost piles, runoff. Wilderness zones — zones of ecological preservation where persons are prohibited except to study or maintain those areas from invasion. ('99)

Definitely don't build any buildings in the Crum. Any expansion that the college needs should go in some other direction. Thanks for doing this. ('00)

I think the Crum Woods [should] be kept as "wild" as possible. I think its greatest asset is as a place for solitary reflection. Anything that interferes with that use should be limited. I would favor barring biking and dog walking in the Crum. Anything that disturbs the peace and quiet of the Crum should be limited. ('00)

If further development has to occur and invade Crum space, please design the building such that the Crum is incorporated into its character. ('00)

Is there now, or will there be in the future, a scientist at Swarthmore that can maximize the Crum's potential as a scientific site? How are the "big bio" students at Swarthmore compromised by the Crum's limitations? ('00)

Just that I would be highly disappointed in the College if it sacrificed the incredible asset of Crum Woods in order to put up a few more buildings. ('00)

Keep it intact! ('00)

More aggressive measures of dealing with the stormwater runoff problem. ('00)

Not a good place for the athletic facilities. ('00)

Please do not develop the Crum Woods — it is wonderful to be able to walk in the woods at any time. It helped keep me centered and focused at Swarthmore. ('00)

Please don't build anything on it or develop it. ('00)

That it is an absolutely vital and essential part of the experience and life of Swarthmore College, its students, faculty, and staff. Please protect it. ('00)

The Crum is a societal artifact, reflecting something of the values of the community that has cultivated it. I think that this should be taken into account when considering its future. Its seems perhaps quixotic to restore the woods to a "pre-European" state, since that would change it entirely. I think that the committee should consider very carefully what kind of ecological community the Crum can most effectively be and set up a stewardship plan accordingly. Certainly, recent aggressive invasives should be curbed if possible. The woods' function as a water-quality buffer for the creek is invaluable and should not be compromised further. My sense is that any further major diminishment of the woods' area will have detrimental effects on the whole suburban landscape in which the woods sits. ('00)

This might sound silly, but is there anything the College can do upstream of the College section of the Crum to affect water quality? ('00)

Although most likely ill-situated, I believe the composting facility is an example of community involvement in conservation as well as a means to increase community awareness of the biological importance of the Crum. Given its easy accessibility, I really think that it is important to conserve the site not only as a recreational space but as a teaching space both for the academic and the socially/environmentally conscious. I am currently working in the conservation field and see that environmental education, and public awareness in general, is greatly lacking from many urban and suburban communities. While it may be difficult to incorporate an environmental curriculum into the school systems, providing accessibility to area students and teaching tools to area teachers could really help young minds grasp the importance of the woods. I also feel that there should be a more conscious effort on the College's behalf to incorporate community impacts of development into their planning. The paving of the Dupont parking lot greatly increased runoff into the Crum, as well as increasing erosion down the already rather steep slopes. I can't imagine that paving over the rugby field to increase parking helped this situation at all, and I am unaware that, already knowing the

impacts of paving Dupont, the College made any special effort to minimize the same impacts of paving when expanding the parking area. Especially now with thoughts to build the new hotel and dorm, etc, I would really like the community to look into possible impacts on the Woods BEFORE they start work. ('01)

For many, it fills a necessary role of a "wild side," a communing with nature, and a peacefulness that can sometimes be hard to find on campus. I feel strongly that development should not be allowed to infringe on the woods. ('01)

I spent three summers on a watershed restoration project for Crum Creek. The presence of the woods and creek provide students with extremely valuable environmental research opportunities. The woods were also one of my favorite places on campus for walking. ('01)

I think it's very important that the woods be left intact for future generations to learn from and enjoy. The woods represents an extraordinary educational resource and one of the few natural areas remaining in Delaware County. Time spent in the Crum was a very special part of my Swarthmore experience, and I think of it as a unique and defining feature of the campus — like Magill Walk, the ampitheater and Parrish lawn. I was troubled by talk of preserving the most valuable parts of the Crum, as if the woods in its entirety wasn't worth protecting. I think every effort should be made to find ways to meet the college's development needs without destroying any part of the woods. I hope that I'll be able to return to Swarthmore many years from now and be able to see the woods in better — not worse — shape than it is today. The Crum Woods is a truly irreplaceable and, I believe, essential part of Swarthmore. ('01)

Please do not develop on any of the space of the Crum Woods. The natural wildlife and forest around Swarthmore College [are] a crucial part of the campus environment. Walking around the forest was a wonderful way to center and relax during a stressful week. ('01)

Please prevent any encroachment on this land. It would be a terrible, terrible lost if it was used for development (parking, buildings, etc.). I would be willing to contribute to preserve it the way it is, or help restore or expand it as a lovely, wooded sanctuary for wildlife and students. ('01)

Access to wild space is important for students — the Crum Woods is small enough as it is, and shouldn't be used at all as space for development. ('02)

A connection to nature is rapidly being lost by members of our society. The Crum provides an opportunity for students to regain some sanity while developing or maintaining a life-long connection to the natural world. It is also an ideal opportunity to learn how to study human impacts on the environment, in addition to more basic ecological patterns and processes. (No class year given.)

Remember that it is a natural place that we are only borrowing. (No class year given.)

Appendix B. Summary of Faculty Survey Results

The faculty survey was conducted by questionnaire distributed by e-mail in an all-faculty mailing on 05 May 2001, the day after the end of the semester's classes. The response rate was 28% of the entire faculty (53 respondents). See also Appendix D, Summary of faculty interviews. Summaries and excerpts from responses to each of the questionnaire items (boldface) are presented below.

How have you or members of your family used the Crum Woods, including Crum Creek and Crum Meadow?

Table B1. Faculty and faculty family uses of the Crum Woods.

	percent
Hiking or walking the trails	98.1
Sitting and enjoying the quiet	77.4
Viewing the plants and landscape	67.9
Watching birds or other wildlife	60.4
Passing through on the way to another destination	47.2
Picnicking	37.7
Jogging or cross-country training on the trails	30.2
Sketching, painting, photographing, etc.	20.8
Dog walking	18.9
Rock climbing	17.0
Teaching/learning (in a class or informally)	17.0
Riding a trail bike	13.2
Volunteer work	9.4
Backyard adjoins Woods	3.8
Swimming	3.8

(Several other responses were received. Each accounts for < 2% of respondents.)

Have you taken any of your classes into the Crum Woods? If so, in which one(s)?

Just once, in the Spring to teach the vocabulary of the woods in French

Shakespeare seminar many years ago

English 70G, Writing Nature. We spent three classes walking through the Crum with Arboretum staff as our guides.

No, but my student teachers and former teachers have. I teach courses called Teaching the Young Learner and the Curriculum and Methods Seminar for pre-service teachers.

Yes, many times. Meeting school classes/not college classes though.

Biology 2

I've taken the students in my Embryology course to the Crum Woods, both at Swarthmore and at the Taylor Arboretum.

Dance Improvisation and Composition classes are regularly assigned a session in the Crum.

I teach a Lifetime Fitness class (Physical Education), and we have done several hikes/walks through the Crum. … I am trying to organize an Outdoor Skills class, which could use the Crum for a small orienteering course.

Perception (Psych 32)

I have taken my Stat 2 students into the amphitheater to do an experiment with soap bubbles. It had nothing to do with the Crum except that I wanted a pleasant, outdoor setting.

Astronomy 1F

Women and Religion

Have students used the Crum Woods as part of an assignment for any of your classes? If so, please explain.

English 70G, Writing Nature. Students had to write journal entries, modeled after literary journals (Dorothy Wordsworth, John Clare, Gerard Manley Hopkins, John Muir, etc.), based on their walks through the Crum. I asked them to focus in on very small details, and then to respond to the woods on a larger scale. I also invited them to address the status of the woods during two weeks focused on activist writing. Many of the students also wrote poems and stories set in the Crum Woods.

English 36, The Romantic Sublime. I sometimes have students write journal entries based on the Crum woods for this course as well.

Only as their own interpretation of an open-ended assignment.

Yes, we were working with the children on understanding stewardship — we collected trash and worked with the children to think about ways in which they could both take care of the environmet and also help others to do so as well. Also, for scavenger hunts, quiet walks, a place to hike and climb together.

Biology 2 animal behavior projects, independent research

Not exactly, but when we have had groups of urban middle school groups visiting campus on several occasions, students have taken them into the Crum and on a couple of occasions someone from the Scott foundation has led the tour. Swarthmore was part of an urban program in NYC for several summers that took middle school students to Black Rock State Forest for three weeks and did environmental science, and when the students visited here we showed off the Crum.

As the subject for some pictures, at the student's discretion.

Again, no, though now that you raise the question it does raise intriguing possibilities for skits, performances, etc.

Yes, filming of videos for class

We have looked at sponge and flatworm embryos in Crum Creek, and we've looked at toad eggs and tadpoles at the Taylor Arboretum.

[For Dance Improvisation and Composition] Students in these classes have the opportunity to explore the Crum and choose an area for site specific performance. They then work on one of a variety of themes, applying it specifically to the environment. The intention is that they be mindful of the way that the Crum impacts their movement choices and how they can choose, through movement, to highlight particular aspects of the Crum.

For English 70 E (Lyric Encounters), as part of a segment focused on the uses of lyric to extol the beauties of nature or satirize the depravities of the city, students were asked to spend a length of time in each environment and write in response to what they experienced and perceived.

I assign my Stat 2 and 2c students to do projects involving data collection and analysis. This semester one group decided to do a survey of the Crum to learn about the prevalence of invasive species.

For several years before I retired I did a lab with Astronomy 1 students in the Crum meadow at the Swathenge stones, in which they examine the stones for astronomicalalignments, determine whether they are laid out true N-S or magnetic N-S (it's the latter — someone just used a magnetic compass in setting them down).

What (if anything) originally prompted you to view the Crum Woods as a potential teaching resource?

The existence of a clearly pastoral setting

I'd been thinking about it for years, just waiting for the chance to teach this kind of a course. I took a community course (Nature Walking?) from Janet Williams the spring before teaching to try to blunt the edge of my ignorance. I'd love to have the faculty be given a chance to learn more about the Crum woods. Next year, for instance, there will be a faculty seminar on the teaching of writing, and interested faculty will be paid $1000 to attend these sessions (once every two weeks throughout the semester). It might not be possible to pay people to attend (though it does improve attendance) but it would be wonderful if faculty themselves could be taught more about the Crum and how to use it in their teaching.

It's there, it's close, it's wonderful.

Its beauty and solitude; its natural (as opposed to landscaped) state.

It was part of Bio 2 before I started teaching in it. Also, I am partly a field biologist.

Its proximity to the college and amount of animal, plant and microbial life

Atmosphere

I feel it important to bring ecological considerations into my course … We spend much time on development in the laboratory, but it's critical to show how development has evolved to occur in specific places.

My own desire to see and experience dance as applicable in places other than the traditional stage environment.

Proximity, potential for solitude, complicated ecosystem

Great walking paths. I encourage walking and hiking as great ways to exercise over one's lifetime. Also discuss the fact that walking in the midst of the beautiful Crum is a fantastic form of stress management.

Visual experience of locomotor navigation in the woods provides important contrast with paved/carpentered environment.

It's a beautiful place to work.

[For Astronomy 1F] The need to get away from campus lights! (Plus the existence of the stones.)

Conversations with members of Biology faculty

Study of religion and nature

In the past academic year, about how many times (in total, or average per month or week) have you gone into the Crum Woods?

Average of 53 respondents: 66.6 (SE = 13.5) times per year.

How do you believe the uses of the Crum Woods should be prioritized?

Table B2. Faculty priorities for Crum Woods use.

mean score (on a scale of 0 to 4))	
3.71	Maintaining the Woods' contribution to the environmental quality of the area
3.52	Aesthetic enjoyment
3.27	Protecting rare species and intact ecological communities
3.26	Non-mechanized recreation
2.96	Opportunities for volunteer community service
2.75	Teaching/learning
2.54	Spiritual reflection
2.54	Scientific research
2.52	Incorporation into the curriculum
1.85	Restoring vegetation and wildlife to pre-European character
0.57	Trail biking
0.48	Development, when land is needed to build new college facilities

(Several other responses were received. Each accounts for < 1.5% of respondents.)

Do you think the college is making use of the Crum Woods appropriately? If not, please elaborate briefly.

Table B3. Faculty opinions on appropriateness of Crum Woods use.

Yes	35.8%
No	13.2%
Maybe	18.9%
Don't know	20.8%
No answer	11.3%

Other answers:

We should consider building more housing.

I think the woods are a fabulous, under-utilized resource. Faculty may need some creative guidance about how they might use the woods in their teaching.

I have no clear idea but feel the woods have not been surveyed and maintained as regularly, systematically and thoroughly as I'd like to see given that the Crum Woods are an invaluable community resource.

Depends on which element of the College you mean. If you mean Physical Plant, the answer is definitely not. If you mean faculty who use it for teaching, yes. If you mean the rest of us who use it in other ways, the answer is sometimes yes, sometimes no.

I'm not sure how the college is "using" the Crum Woods, other than maintenance and benign neglect.

Not always. I am disturbed by the black-topped field on the far side of the Crum, for instance. It used to be a beautiful wide-open meadow in which I would find snakes, box turtles, wood turtles, toads, woodchucks, and hawks. Now it is a huge parking lot, used only for a place to store decaying leaves. The fauna have largely disappeared.

I fear the college will destroy parts of the Crum in its headlong rush to development. As far as I understand, the college will make a set of decisions without any input from a long range planning Committee, about such issues as the Hotel, parking etc and this will suddenly create new urgent needs (e.g., the need for new athletic fields) and the structure will be put in place where there is irresistable pressure placed on developing or altering the Crum. Unless decisions about land use at the college are made with an eye toward the community as a whole, and made by a Long Term Land Use Planning Committee, involving a wide range of community members, I think the Crum will be seriously and needlessly damaged.

Active stewardship, not active usage, is what is appropriate. Having it as a place to enjoy is the most important usage. I think this is close to the current usage.

Preservation of the wooded nature of the valley is good. Beyond this, I don't really know what college policy is.

… Could do more in the form of trail maintenance, new trail creation, building of bridges for a circular path etc.

For the most part, yes. But it needs to be better protected from changes on campus and the surrounding area.

No — I believe the College is planning to significantly degrade the Crum as part of a major reconfiguration of land use designed to accommodate an expansion of the student body. This is not fancy on my part; just a month ago at a small meeting with the President he informed us of his land use and student body increase plans.

I have great concerns about the College plans to develop the Crum.

Do you think the college is taking care of the Crum Woods appropriately? Please elaborate briefly.

Table B4. Faculty opinions on appropriateness of Crum Woods stewardship.

Yes	24.5%
No	26.4%
Maybe	17.0%
Don't know	15.1%
No answer	17.0%

Other answers:

Trash cleanup, trail maintenance, invasive plant removal, forest restoration should be done more often.

No, I think the college has largely ignored the woods, leaving it up to the Arboretum to struggle with invasive exotics, misuse, etc. Current plans seem focused on development rather than conservation or stewardship.

… I believe more could be done but am not very well informed on this issue.

Only if you think that constantly degrading it by using it as a dump and a place to build things, yes. But I don't, so no. Beyond the disruptions visited upon the Woods, simple maintenance has been woefully inadequate.

… I've appreciated that it was not manicured. I don't know what returning it to the state prior to settlement would entail. I think it is important as a place to be that is different from the more built up portions of campus.

Well, it has low priority, and I've seen trash and erosion left sitting a long time, but I think the college does have more pressing financial concerns.

I believe they are doing a reasonable job, although there are places where exotic invasives are taking over the forest and driving out native species.

Too much trash around railroad bridge, not enough patrolling by campus police

There is scum in the slower moving parts of the Crum. There are industrial pipes and garbage that hasn't been cleaned in years. There appear to be many more dying trees, too. I haven't seen salamanders or turtles in a few years, either.

The College needs to handle water runoff more appropriately. There is too much erosion due to drainage from the campus area.

The level of care needs to be increased. Is this solely the College's responsibility? The borough's? The Scott foundation's? All 3?

We need to address the run-off situation and consider some serious investment in dredging and restoring the watercourse. Imagine if the Crum were more like Ridley Creek … that would considerably enhance its beauty. As is now, water quality is pretty bad on average.

There is obvious, widespread, and serious erosion, caused in part by improper stormwater management related to parking lots and buildings. There is overuse, causing damage to vegetation along the trails, impacted soil, etc. Trail bikes, especially ridden by kids, have caused a lot of damage. Although the College isn't responsible for the debris that gets into the Crum, it should be removed, especially non-natural materials and tree limbs or anything else that blocks the flow of water. For the health of the woods, the College may been to consider restricting their use, even though the woods have provided an important amenity for the larger community and made up for a conspicuous lack of public parkland.

I think more could be done to stop the invading vines from engulfing all of the trees and bushes.

Have you seen evidence of misuse of the Woods, either by students, community members, or the College itself?

Table B5. Faculty observations of Crum Woods misuse.

Yes	49.1%
No	18.9%
Maybe	7.5%
Don't know	0
No answer	24.5%

Other answers:

Plant theft, graffiti on rocks, mountain bike damage

Beer bottles/cans, broken glass, etc. I do think mountain biking takes a real toll on the area. Current plans to develop large playing fields on the far side of the Crum seem to me a sign of abuse on the part of the College.

Trailbiking seems to cause lots of abrasion and consequent erosion.

Broken glass in places.

More neglect. But questionable drainage uses.

Yes, by all these groups.

Trash, people who don't clean up their dog's waste, vandalism to wooden benches.

Trash is an example. It appears that there are beer parties at times.

Graffiti, litter

I think trail bikes in the Crum are destructive to some of the trails, especially when they are wet.

The amount of trash, including lots of beer cans is clear evidence of the misuse of the woods. I have also seen people riding bikes off the trails, and dogs off leash.

There is some litter, which i am sure is misuse. I personally feel that trail biking is misuse.

I've seen a lot of litter, presumably dropped by students and/or community members. What bothers me most (as a parent but also in general) is broken bottle glass, since it's hard to get it all picked up and of course can cut a careless clambering hand or foot.

Trash strewn area around Stonehenge and railroad bridge, shooting of guns by teenagers, rough biking, underage drinking, destruction of young saplings along shore

The building of the parking lot by the water tower. Other than that, no.

Trash. Personally, I think running in the woods is dangerous, since I've seen people fall when walking on rocky or rutted parts, but others don't seem to find running there as fool-hardy as I do.

Some garbage … not clear where its source is. I am concerned a bit about the sewage lines that seem to run through the area … where do they dump? Pavement and construction has clearly made runoff and erosion a worse problem over the years. And the community seems to view the woods as one big dog toilet, which annoys me somewhat. We see a lot of people parking here at Crum Ledge to walk their dogs; some of them are very irresponsible both in terms of curbing their dogs and in terms of allowing their pets to harass birds and other animals (and occasionally people). Noise from 476 also bad, but nothing to be done about that.

There seems to be a fair bit of construction residue. (gravel trails). There is, of course, graffiti and trash by the railroad bridge.

I often come upon piles of empty beer cans and other trash.

What else would you like us to consider pertaining to the use and stewardship of the Crum Woods?

Answers:

I would like to enjoy looking at the stream without thinking it's in bad shape. It's not really clean and plaisant to look at. The college should use some workers to take good care of it. Sometimes, big pieces of wood are blocking the way for too long.

What are the costs? Hard to compare benefits without costs.

I'm mostly worried that by the time the Stewardship Committee is able to make any recommendations, the college administration will have already tied its hands by abolishing existing playing fields. So time seems to me of the essence here. I think the college has to be brought to some recognition of stewardship responsibilities <italic>before</italic> the proposed inn is agreed upon and more fields are lost. I think it's all too easy for the college to force development and then say, "Oh, of course we think conservation matters," after they've already squandered substantial portions of land. (Sorry if my language is inflammatory here.)

Clear deadfalls off paths; control washdown and gullying; provide more litter containers so that picking up trash and glass doesn't require carrying it so far for disposal; clear trash out of streambed.

Some labeling of trees and plants, as on campus by the Scott foundation, might raise community awareness of ecological issues.

I think that you need to come up with some way of educating visitors as they arrive at the various entries to the Woods (i.e., something about not picking flowers, about sticking to the trails, and the like). There also needs to be some enforcement. In my more than a quarter century of using the Woods, I have NEVER seen a College cop there, so the Woods have

become a kind of free zone for all kinds of underage drinking and drug use (the high school kids treat it as a party spot, as do some College kids), as well as a place where people feel free to misuse the environment. The College's example (little maintenance when not positive harm, as with dumping and thoughtless construction) has been pernicious here. Of course, many, probably most, people who use the Woods try to use them well. But such an ecologically sensitive place easily shows the ill effects of those who used it badly.

I think the Crum Woods is one of the College's most precious contributions to the town community and its quality of life. I hope that, although the college owns the woods, that it will see the woods as having more stakeholders and a larger constituency than only itself.

An education effort that provided information — not lectures, but perhaps via e-mail updates, news articles, etc. that apprised us of the wealth that is the woods and also what is necessary to maintain it.

I just think it is very valuable to have a place of natural beauty and quiet close to where one works. The Crum was crucial to me in that way when I was a student. Alas, it's value is greatly reduced due to the continual noise from the Blue Route. I am sure the noise barriers have helped, but not enough. If you could figure out how to make the barriers much more effective, that would be a big improvement.

Ways to keep the creek clean.

Insist that the college set up a long range land use planning committee so you are not trapped into changes that seem inevitable.

My highest priorities for the Crum are restoring and/or maintaining the ecological well-being of the woods and permitting/encouraging scientific uses as well as non-mechanized recreation. Here in the suburban Philadelphia area, we need to preserve open spaces and diverse habitats wherever possible, and the Crum is a great opportunity to do so right on our own campus. I also think we should be focusing on restoring native plants, especially at the streamside, and removing the invasive exotics (e.g., Norway maple, Japanese honeysuckle). To this end, encouraging community-based volunteer activities would be welcome. The Scott Arboretum should be using more native plants throughout the Crum holdings, and serving as a resource for individuals interested in restoring similar habitats.

Providing a trail map would be great — and maybe blazing the trails????

I had one comment about mountain bikes: I grew up in Colorado, and the idea of a big heavy person going fast on a bike down a hillside, through some flowers, etc., because the trail is blocked or too bumpy with big rocks just makes me cringe. But probably the ecosystem here isn't as fragile, so if they do that it will still heal before too long? I've had to scoot out of the way of people on bikes a couple of times, and wondered at that time whether it would be good to label a couple of trails as bike trails, so the poor pedestrians, moving slowly and perhaps not making any noise that a biker would hear from a distance, could expect to have to have to jump out of the path of someone who was really enjoying going fast?

Make sure that responsible dog walkers are and will remain welcome in this, our only closeby open space in Delaware County! Putting signs clearly explaining rules and regulations (like "pick up after your dog") at entrances to Woods. Provide garbage cans (and their routine maintenance) in different areas to prevent littering.

Thanks for asking. First, I have a grant with Scott McRobert, an animal behavior biologist who is a breeder of endangered reptiles at St. Joseph's University. We are building a turtle breeding facility to be housed at St. Joseph's, but which is legally under our jurisdiction. Scott and I were

seriously considering the possibility of using our breeding facility to breed eastern box turtle and wood turtle embryos for release into the Crum Woods under the appropriate supervision. The Crum Woods used to house both species. Can we bring this up with you? Second, is the flow of Crum Creek dependent on the reservoir above it, and if so, could that be responsible for what appears to be a paucity of amphibians and fish in the stream?

I've heard of plans to use some of the land for building or for playing fields. With wooded land so endangered in this area, I believe this would be an irresponsible choice, and I'd urge the committee to take a stand on the issue as soon as possible.

I know that there are many restrictions on space at the College. With the construction of the new science complex and the hotel, the athletic department will be losing significant field space. The Crum field has been mentioned as a potential site for future athletic competition. I really don't know what to think about that

I think it would be useful to put a simple bridge across the Crum to better connect the two sides of the woods. It can be difficult to cross the Crum during certain months of the year, and this would allow more members of the community to utilize the full woods area.

The Crum Woods stewardship initiative should be explicitly coordinated with a land use planning committee that the college should establish immediately.

What are the plans for the stone circle in the Crum meadows?

… There is actually a pretty remarkable variety of bird species in the woods — we've seen a lot in five years at Crum Ledge. To my surprise, bullfrogs also seem to be hanging on, and there's an upsurge in sunfish (I think that's what they are) the last two springs. Water is clearer this spring, too.

Call more frequently for volunteers to pick up trash and clean up the trails.

A small walking bridge would be wonderful. As it I either have to wade or balance on a downed tree (which my dog refuses to do) to get across.

Getting wider college discussion of the crucial environmental importance of the Crum Woods area.

Appendix C. Summary of Student Survey Results

The student survey was conducted by questionnaire distributed by e-mail in an all-student mailing on 05 May 2001, the day after the end of the semester's classes. As an incentive, three respondents' names were drawn at random to receive a large pizza at the town's most popular take-out restaurant. The response rate was 28% of the entire student body (206 respondents). Summaries and excerpts from responses to each of the questionnaire items (boldface) are given below.

How have you used the Crum Woods, including Crum Creek and Crum Meadow?

Table C1. Student uses of the Crum Woods.

	percent
Hiking or walking the trails	89.8
Sitting and enjoying the quiet	80.6
Talking with friends	70.4
Viewing the plants and landscape	63.1
Jogging or cross-country training on the trails	53.9
Passing through on the way to other destination	48.1
Watching birds or other wildlife	42.2
Course work	41.3
Picnicking	34.0
Sketching, painting, photographing, etc.	34.0
Swimming	20.4
Sleeping outdoors	19.4
Rock climbing	18.9
Research	15.0
Riding a trail bike	9.2
Bonfires	5.2
Meditation	1.9

(Several other responses were received. Each accounts for < 1.5% of respondents.)

Have you been in the Crum Woods during any class(es)? If so, in which one(s)?

Table C2. Students' listing of classes that met in the Crum Woods.

Art	Studio Art	3
	Foundation Art Class	1
	Drawing	1
	Photography	1
	Oil Painting	1
	Watercolor	1
Biology	Bio 2/Intro. Biology	57
	Ecology	8
	Field Ornithology	5
	Chemical ecology	2
	Evolution Seminar	1
	Animal Physiology	1
	Invertebrate Zoology	1
	Animal Behavior	1
	Systematic Botany	1
Education	Education	1
Engineering	Water Quality and Pollution Control	2
	Intro. to Environmental Protection	1
English Literature	Writing Nature	6
	Freshman English	1
	English intro Cultural Practices & Social Texts	1
History	Environmental History	2
Modern Languages	Spanish	1
Music & Dance	Dance	6
	Modern Dance	4
	Modern Dance I	2
	Music 40	1
Physical Education & Athletics	Physical Education	1
Physics & Astronomy	Earth Science	4
	Astronomy	2
Theatre Studies	Acting 2	1

Have you been in the Crum Woods as part of any class assignment? If so, for what class(es)?

Table C3. Students' listing of class assignments performed in the Crum Woods.

Art	Studio Art	4
	Foundation Art Class	3
	Photography	2
	Drawing	1
	Oil Painting	1
	Watercolor	1
Biology	Bio 2/Intro. Biology (labs)	39
	Ecology	7
	Field Ornithology	3
	Chemical ecology	2
	Animal Physiology	1
	Invertebrate Zoology	1
	Animal Behavior	1
	Evolution	1
	Systematic Botany	1
Engineering	Water Quality and Pollution Control	1
	Engineering Design	1
	Environmental Studies Capstone Seminar	1
	Intro. to Environmental Protection	1
English Literature	Writing Nature	5
English (continued)	Lyric Encounters (poetry writing)	2
	Freshman English	1
Mathematics & Statistics	Stat2C	2
Music & Dance	Modern Dance 2	2
	Dance	1
Philosophy	Philosophy	1
Physics & Astronomy	Astronomy	3
	Principles of the Earth Sciences	1

How were you FIRST introduced to the Crum Woods?

Table C4. Students' first introduction to the Crum Woods.

Freshman orientation	49.5%
Wandered in one day	13.1%
Friends took me there	5.8%
Track, running on the cross-country team	2.9%

(Several other responses were received. Each accounts for < 1.5% of respondents.)

In the past academic year, about how many times (in total, or average per month or week) have you gone into the Crum Woods?

Average of 206 respondents: 22.2 (SE = 2.2) times per year.

How do you believe the uses of the Crum Woods should be prioritized?

Table C5. Student priorities for Crum Woods use.

mean score (on a scale of 0 to 4)	
3.45	Maintaining the Woods' contribution to the environmental quality of the area
3.24	Aesthetic enjoyment
3.21	Protecting rare species and intact ecological communities
2.89	Non-mechanized recreation
2.63	Teaching/learning
2.55	Spiritual reflection
2.53	Opportunities for volunteer community service
2.40	Scientific research
2.26	Incorporation into the curriculum
2.04	Restoring vegetation and wildlife to pre-European character
1.45	Trail biking
0.43	Development, when land is needed to build new college facilities

(Several other responses were received. Each accounts for < 1.5% of respondents.)

Do you think the college is making use of the Crum Woods appropriately? If not, please elaborate briefly.

Table C6. Student opinions on appropriateness of Crum Woods use.

Yes	46.6%
No	13.6%
Maybe	5.3%
Don't know	5.8%
No answer	28.7%

Representative sample of answers:

I'm not sure. I always wish I knew more about the woods. I would also really appreciate a map of the trails.

The college likes to advertise the Crum as an attraction at Swarthmore — as if it were a theme park. Once students get here, there is no sense of how we are responsible for the care of the Crum or the campus. We never have to clean it up. We never see it unless we want to. It's easy for the Crum to drop out of our consciousness — even when we get excited about building new paths, buildings, ramps, etc. I would like to see more opportunities for students here and everywhere to participate in the Crum. I would like to see the Crum used as a resource. I've seen woods that groups have used to teach conflict resolution skills. In Writing Nature, the Crum was used to educate us about biodiversity.

If I hadn't taken Bio 2, I'd know almost nothing about the Crum Woods, other than what the parts closest to campus look like — and I still don't know all that much. It seems like there's a lot of potential to inform students about the woods, which could have an impact on people's priorities. I think in general, the woods are underappreciated, and that that's mainly because students really have to take a lot of initiative to find out about them.

Currently, I think the use of the Crum is appropriate. However, the plans to put athletic fields there worry me greatly. One of the things I love about Swarthmore is that it's possible to take a brief walk and find oneself in a place where one can pretty much ignore civilization, even if its presence can be detected at the periphery. Putting any kind of organized development in would destroy that feeling.

I know little about the use the college makes of the Crum Woods. I appreciated the Bio 2 lab walking in the woods immensely — it offered me the opportunity to look closely at the details of the world around me, which I sometimes lose sight of.

Yes, in a way I think the college should take care of the woods but leave them alone too. Let them be an oasis and a getaway for the students

I know that biology and ecology classes routinely use it during lab sessions or for nature walks. I don't think that the College itself necessarily has to take an active role in promoting the Crum's use; students find uses for it themselves, whether it be jogging or reading or whatever.

Although I might personally like to have more classes involve the Crum in the curriculum, or even be taught in the Crum, weather permitting, regardless of their curriculum, I understand that this is not a policy the school could practically adopt, as it makes matters difficult on those w/severe allergies or physical handicaps. In fact, the most I feel I can reasonably expect from the school is that it makes certain that its students may continue to enjoy the Crum on an individual basis.

Yes, though I think the college should really try to integrate the woods into more classes than the env. studies ones. To have to go to the Crum woods whether you're a classics or a physics major at least once in four years for your classes should be a mandatory. Also, student-guided freshman tours of the Crum would have really interested me as a first-year.

Yes and no. I think that the uses that the college have are appropriate, but I think that more people should take advantage of the Crum than actually do. I think that most students, when they visited, thought they would go down to the Crum a lot, but few do

Yes, in the sense that it has not been developed AND SHOULD NOT BE

I think the way the college uses the Crum now is perfect. I've heard rumors that the college is planning to pave over part of the woods and "build new college facilities" (as you put it) there. This idea fills me with revulsion. If that's why you're taking this survey, then know that I feel that destroying any part of the Crum would be a crime. Leave the Crum alone. You have no right to take it away from us.

Yes and no. I think it's great that a lot of profs are incorporating the Woods into their course work. However, I think the Crum could perhaps be part of the curriculum in a more "institutional" way. I.e. the Crum's official purposes should be teaching and conservation. I also think the trails could sometimes be maintained a bit better for running and hiking. A map of trails in the Crum would be wonderful!

I suppose so — I'm glad there aren't many things that the college does there, since I like to see it kept quiet. I like to see it kept mainly for the enjoyment of students who just need a break from the hecticness of school, which doesn't really need any involvement by the college.

I do think the college is making use of the Crum Woods appropriately. At the encouragement of the college, students use the woods for many reasons, from class projects to personal reflection. By preserving the trails in the woods, the college provides its students from more rural areas with a place where we can feel more at home.

I think so. I think support should be given to classes and people who want to research in the Crum, and I think it should be kept more or less the way it is now; it's a wonderful place to go for any number of small personal activities, and as a way to get off campus and away from Swarthmore without going into a major urban area (closer, too).

I guess … maybe more little picnic places? benches? picnic tables? spots to stop and rest on the trail? bridge over the creek?

Yes, I am glad to see that plans for the new dorm, etc. do not impinge on the Crum.

I'm not quite sure *how* the college is making use of the woods. Basically, all I care about is that what we do makes the well-being of animals and plants the first priority.

Yes and NO. In the decision to leave the Crum out of current development plans the college is properly handling the space. However, I also feel that the College could be doing more for the Crum in terms of restoration and maintenance.

I think so. More classes could work the Crum into their syllabus (I'm a humanities person so this is more the area I'm thinking of; I don't have personal experience with the sciences, but hear that bio classes at least seem to make use of the woods when appropriate)

At this point the college is not making full use of the wood as it has potential to, although on another hand I want the woods to stay untouched, pristine and not flooded with classes or people. people could use the wood more creatively — I am thinking of the arts in particular.

I think that most students are given the impression that the Woods just exists there without any singular purpose. We don't really know what we can do in there, if we are even allowed in there. I think the college should increase awareness of it, and the various activities that are associated with it.

I am happy to see that the college created a committee to manage the Crum, because it is really essential to the teaching pledge of the college, as well as to the quality of life of the students and surrounding community members. I think that only the Biology and Engineering Departments (and maybe Art) are taking advantage of the great teaching value of the woods. Students make pretty good use of the Crum, if only for trail running. The Arboretum attempts to do some outreach to the community about the Crum, but it might be improved (I liked that the Bios club had two tree identification walks with an intern in the Arboretum. these types of things should be regular)

Currently I think the College could incorporate awareness of and study of the native ecosystem for a variety of curricular and extracurricular projects, such as through facilitating hikes among members of the Learning for Life program, Chester tutorial, etc. For the future, I fear what rumors imply about building athletic fields on areas of the Crum Woods.

Do you think the college is taking care of the Crum Woods appropriately? Please elaborate briefly.

Table C7. Student opinions on appropriateness of Crum Woods stewardship.

Yes	31.1%
No	14.6%
Maybe	2.9%
Don't know	22.3%
No answer	29.1%

Representative sample of answers:

Almost. I think more effort should be made to clean the area up, but using student volunteers and using college resources.

I think and effort should be made to keep the area fairly wild. Things like the new signs the college installed a year or two ago made the area feel developed, and I think it is important to feel like one can "get away" from the human development around here.

No, I think the college could treat the Crum more like a resource instead of just a bunch of land "over there" that's not actively used by the college.

Although I do not know what the college is doing to take care of the Crum, I hear all the time that it is so incredibly polluted and that it's a dump, and I therefore don't think much care is given while all the priority is given to flowers on campus which I do not think is as important.

I'm not sure whose responsibility this is, but erosion and trash clean up are two things that need to be attended more closely.

Yes, but more of an effort should be made to get rid of non-native species (Norway maple) and to clean up the trash that people leave around

… Particularly with the plans for sports fields at the stockpile site, in association with the new science building, the new dorm, and the possible hotel, I don't have a sense that "conservation" is the college's highest concern (not that it's entirely out of the picture).

… I was quite surprised to see two ducks swimming in it last week, as I've never seen anything like fish or birds in the water. I hope we keep it foresty and don't cut into it.

I went for a walk in the creek yesterday — it was filthy. I don't mind the mud, it is the hub-caps and bottles and scrap metal that bothers me. I am disgusted that we do not have more respect for the creek. it is so beautiful. it should be cleaned up. The trails are kept up nicely, but there is broken glass on them, too. How can we keep students and others from drinking and leaving their bottles down there?

… More attention should be paid to keeping the woods as natural as possible for native animals and vegetation.

Need more trail signs

… Fully knowing that the Ville is utterly uncooperative, the college should plan ahead and conserve space. Rather than doing this, they're building, of all damnable things, a hotel; and in 50 years when another dorm needs to go up, trees will have to come down.

I don't think so, but again, I'm not sure. But there seems like there is a lot of erosion in the Crum, and I think a big part of that is all the college's building projects. …

More funds should be directed to environmental restoration & removal of non-native species.

No, I think the college needs to put in a lot more work fighting erosion and the mountain bikers.

Not as well as they should. I would like the whole area (including the creek) to be cleaner.

Not completely. I come from Vermont, and I always feel a bit more at home when walking or running through the Crum. In short, the natural environment provided by the Crum is very important to me. Personally, I feel that the college should attempt as much as possible NOT to develop the area and to protect its biological diversity.

I do think the college is taking care of the Crum Woods appropriately, with two reservations: First, trash cleanup efforts could be more extensive (although I am grateful they exist at all). Second, I have heard stories that the Arboretum staff is managing parts of the Crum Woods for purely aesthetic reasons, as it might a garden. These stories may not be true (I am ignoring the obvious management of the pine grove above the meadow, which I don't consider part of the woods). But if they are true, such management would be inappropriate. The aesthetic appeal of the Crum woods derives from its status as a wild place, not from its status as a big arboreal garden. We already have the rest of the campus for a garden.

I think they're pretty good about taking out invasive species (Norway maple, lantana), but they seem too ready to encroach on the Crum for further development of campus buildings and facilities.

It bothers me that every time an idea for a new building comes up the first thing that happens is we find which part of the Crum is going to get knocked down. While up to now it's been fairly small patches of land, I fear that when a few more projects add up (especially the possibility of moving athletic fields into the Crum, it will alter the habitat dramatically and make the woods worthless for birds and animals.

The creek needs to be cleaned up, and the petroleum and other pipelines running through the woods concern me.

I am always disturbed to see trash and bottles down in the Woods, either along the paths or in the Meadow. I would like to see the Crum as clean as the rest of campus, either through organized clean-ups or volunteer times …

I don't feel that I know enough about the College's maintenance practices with regards to the Crum Woods to answer this question very well. Perhaps a step forward would be to make the College's relationship (maintenance of, plans for) the Woods public knowledge. I think your involvement in this re-thinking and development process could be very useful in this awareness-raising respect.

I think it is great that the college is making efforts to maintain the Crum. I think if anything, these efforts should be a little more aggressive. It is, after all, one of the last wooded areas remaining in this area.

… They should have required a green team when constructing the Mullan Center.

No. I don't think the college officials who are in a position to most significantly impact the Woods are even sufficiently aware of what they have in the Crum, and how it operates ecologically or what it needs. That they are bringing in informed consultants is promising, as at least someone is aware of the ignorance and the need to correct this. …

I think the focus should be more on general threats including encroachment than on little things like the maples.

I don't know much about this but I am concerned about what policies are in place to ensure that college "development" does not encroach on the Crum. I haven't heard of any plans on the part of the college that would affect the Crum negatively but I would be very upset if there were any.

There's always a lot of trash lying around: cans, bottles, broken glass, the like. "The College" isn't putting that junk there — individuals are — but insofar as the college is steward of the Crum, it ought to show more concern over these abuses. Students have led cleanup efforts in the past, and I think it would be worthwhile for the College to encourage such efforts. The College could provide assistance with a student-organized group — supplies, recruitment assistance, recognition — or could start a group itself, perhaps one providing student employment opportunities.

The Crum Creek Monitoring Project is a wonderful example of intersection between student, curricular, and Collegiate interests, but is primarily the result of initiative on the part of environmental-engineering-minded faculty. Regardless, it is Good. …

What else would you like us to consider pertaining to the use and stewardship of the Crum Woods?

Representative sample of answers:

Maybe creating maps of trails or good places to picnic; creating more places good for picnicking (e.g. some picnic tables).

Perhaps a map of the trails somewhere (maybe at the trailheads on all the paved roads). I usually only have a vague idea of where I'll end up when I start out on a trail.

Just to make sure that there is a balance between the health and beauty of the Crum and its use by the college and students. Thoughts of a footbridge crossing the Crum so that students can access fields that will be displaced in the future is a little disturbing, because I don't want to see an overuse of the Crum or the destruction of certain areas.

I'd like to see the school first do what it can to stop negatively impacting the woods, and would like to see them try to restore some of the biological integrity of the ecosystem, so that they can use the woods to teach what a natural ecosystem should be more like. I'd like to see the school do more community outreach and education about the woods, working through local schools, etc. I'd like there to be a pristine, beautiful environment that is cared for on an expansive level, i.e., considering the impact on the woods in all campus planning. I'd like the school to put into practice the ideas of a green community that it advocates, and then use that model as an example and teaching tool of what can be done by others.

The woods were a big factor in my decision to come here — I was quite torn between the opportunities of going to school in a metropolitan area and my desire to remain near some sort of forest — I have lived within walking distance of a recreational forest for most of my life and really cherish the opportunity for easy access to trails and solitude. Thus, I found the combination of the location of Swat and the Crum Woods as a perfect combination. I have been amazed at how few forests there are on the East Coast than on the West Coast, my home. I have also been surprised that there seems to less of an emphasis on preserving the forests here, and think that Swat needs to take a stance and be certain that it is helping the environment in its decisions concerning the Crum Woods, rather than hurting it or even maintaining the status quo. In the Crum Woods, Swat has a responsibility to make an environmental difference in the area.

Keep it as it is. Perhaps people should be encouraged to make better use of it, but the most important thing is to have a place where people can go to relax and enjoy nature, such as it is. I don't think there's much point in trying to make it a haven for rare species or trying to restore to pre-Eurosettlement condition — it's too small for either of these to have much hope of succeeding, and both would destroy its usability for other purposes, what with the requirement of wiping out all the opportunistic plants that have moved in. It's already nothing close to wilderness, and it seems silly to try to create wilderness in a place like this. It should just be there to be enjoyed for what it is — a nice, green place to relax.

Preservation and restoration is the most important goal the college should be concerned with. The outdoors is not something to be molded to meet the needs of people, but rather a part of the environment that should be protected in its natural state, and enjoyed as such.

A couple of suggestions. If possible without disturbing the environment too much, it would be nice to put in a picnic table or two near the Crum. Second, it might be nice to install a few garbage cans throughout the paths.

… As a rugby player whose team hasn't even been guaranteed a playing field for next season, I understand the need for more and better field space, but I don't think it's worth disturbing the Crum. There are better ways to address the athletic space problem (i.e., don't turn existing fields into parking lots/hotels/other non-green things!).

I would like you to consider that the college's administration has already made its share of controversial decisions this year without the student body's input. If you destroy part of the Crum, it will show that the administration truly does not respect us. We live here. I personally am not putting my family through the hardship of paying thousands of dollars in tuition so you can destroy part of the campus.

Should be a serene place for reflection and escape and inspiration. As expansive as possible. More people should be aware of the woods' magic (the science/art associated with them). Unbelievably valuable.

Since students will swim in it regardless, water quality should be a priority.

I have also heard stories of plans to build an athletic field on the far side of the Crum, and make a path through the Crum for students to get to and from the field. While I have no problem with student traffic in the Crum, student THROUGH-traffic is a different thing. How will students treat the Crum woods when the beauty of the woods is not part of their reason for being there? Most, I am sure, would be respectful of the Crum. But how much damage might a few disrespectful students do, walking through the woods on a daily basis? …

The presence of the Crum Woods is one of Swarthmore's greatest assets. It absolutely should NOT be developed for college facilities. If one day lack of space became a serious problem we should build a 50-story skyscraper before cutting into the Crum Woods.

I think it's important to consider that for a lot of students it's a haven, a resource that they don't necessarily use all the time but which it is vitally important to have. The way some buildings, like Cornell and Lang, work with the area to shade in a little rather than cutting off, makes the college feel like it has a much more symbiotic relationship to the woods. I think I'd be heartbroken if development projects started up in the Crum itself, because for me the contrast between the relative quiet (the Blue Route is audible but not too intrusive) and the constant activity of the college is really important.

"Those who contemplate the beauty of the earth find reserves of strength that will endure as long as life lasts." —Rachel Carson, _The_Sense_of_Wonder_

The Crum plays a very important role in student life simply as a place to go and relax; many students don't have time to take day trips hiking, and so the woods fill an important need. I was delighted when I discovered that the College has this resource; it's wonderful to be able to take a walk somewhere quiet. I feel that this use of the woods should be kept in mind, as a higher priority even than pedagogical uses the woods could have.

How can the arboretum and college community be more involved? Why don't we have EarthLust/Scott Arboretum/Deans office clean up drives once a semester?

Taking a development/land easement on all of the land in the woods might be a great step to work towards, so that the College (and anyone else) could never ever develop that land. As long as this committee is in existence, it will likely be able to steer administration's policies, but it has no real power to stop development. There needs to be more of a guarantee that when I come back for my 50th reunion that ALL of the Crum Woods remains intact and undeveloped. …

I'm somewhat ambivalent about encouraging hordes of people to go down there, but to increase awareness, one could make maps of the trails available to students and the college community through key handouts such as in orientation and prospective student packets, as well as in a prominent place on the Swarthmore website, etc.

Appendix D. Stakeholder Interviews

FACULTY — 18 AND 23 MAY, 2001

Attending: Betsy Bolton, English
Tim Burke, History
Scott Gilbert, Biology
Tom Hunter, Mathematics
Mark Jacobs, Biology (Chair)
Art McGarrity, Engineering/Environmental Studies Concentration
Jocelyne Noveral, Biology
Ellen Ross, Religion
Prue Schran, Physics and Astronomy
Mark Wallace, Religion/Environmental Studies Concentration

How do you currently use the Crum Woods?

Personal: Walking, amateur horticulturist, casual but significant

Walking with children, frequent

Tours with friends/children

Recreation with family (birding, animals, insects), running, refreshment

Birding, hiking, lives adjacent

Recreation (hiking, dog walking, children fishing, bikes)

Passive recreation

One of primary uses by town is dog walking; many park near tennis center and walk.

Teaching: Setting for student projects

Occasional, hands-on experience for students

Doesn't think faculty use Crum Woods except for woodsy types.

Living lab for courses (Crumhenge — man's place in nature, meditation, readings in how other cultures view nature/religious traditions); invaluable

Doesn't use for classes — perhaps social events.

Uses it for many classes.

Uses creek for environmental engineering course — water quality of local streams; senior design projects. Has grant to assess problems of lower Crum Creek. Goal is to develop projects and prioritize and coordinate with local municipalities.

Basic introduction to ecology, botanical studies — nature vs. invasive introduction; basic forest structure; effects of erosion

Organized biology; walks within the Biology Department (good way to introduce people to Woods)

What are your concerns about use and management of Crum Woods?

Believes salamander population has been diminished by excessive passive use.

Unleashed dogs

Mountain bikes are potential erosion problem. (Can we designate a given trail for mountain bikes?)

People need to be educated about value of Crum Woods.

Concerned about development — senses that Crum Woods is seen as first ground for development.

What is legal status of Crum Woods?

Borough does not appreciate value of Crum Woods — trusts/assumes the College knows what it is doing.

Can we do a brochure on Crum Woods to orient new students and faculty to values of, rules and regulations?

Need to educate administration and Board of Governors.

Need land-use planning committee.

Key is finding other areas for development.

Concerned that it not be developed or degraded.

Thinks Blue Route has dulled peoples' concern.

Runoff from Dupont parking lot goes right into Crum Woods.

What on campus is affecting Crum Woods?

Thinks convenience is driving development decision. Doesn't think there is a clear vision of land use on campus — things are hidden from community.

Need a permanent voice/advocate on campus to make sure things are/aren't done.

Problem is benign neglect, not conspiracy.

Concern is misuse by College — development.

Should be used for passive recreation. Used too aggressively now.

Dogs, dirt bikes

Crum Woods have survived due to benign neglect; afraid College wants to grow into Crum.

No public plan for Crum Woods — not a conspiracy but no structure. New hotel will eat up land and put added pressure on Woods.

Expansion of athletic fields across Crum. Once infrastructure is built to breach Crum Woods, will lead to further degradation.

College sees it as expendable space.

Not as concerned with all development but breaching Crum to build athletic fields is bad. Doing so would "break the seal" and open up to further development. While Crum Woods are not pure and wild, it is a special place and valuable for academics (unique space — removing would force classes to travel for same use).

Rezoning of housing area

No coordinated stewardship of Crum

Focus has been on getting individual projects done, which have picked away at the Crum Woods. Concerned about biocide use on playing fields. Parking is big issue.

Stormwater controls have been incorporated into design of athletic fields but have not been maintained.

Recommendations by Andropogon have been largely ignored. Small, uncoordinated movements away from benign neglect of Crum. This could be initiation of land-use policy.

Bad idea to develop. Rare to have woods next to college campus and administration; should appreciate it.

What would you like to see happen in the Crum Woods?

Turtle restoration desire, has a breeding facility at St. Joseph U. through grant.

Have annual workday for college community.

Mobilize students, letter in *Phoenix* and *Bulletin* to galvanize alumni.

Clash of values between development and non-development; need to make plans public.

Create "Friends of Crum Woods."

Would like monitoring station.

Used for more research; sophomore independent projects; projects on soil structure; different plant community data collection and observation — backs up class study.

There should be a community-wide discussion of use of the Crum Woods.

Al Bloom has recommendation that a new land-use committee be formed — perhaps by fall of 2001. All new land uses have a potential impact on Crum Woods.

Is it feasible to have an effect on water quality by restoring Crum Woods?

Design stormwater controls for new construction that will improve water quality and be teaching guide.

Need land-use committee! Land-use decisions now made by Facilities and President.

FACILITIES — 6 JUNE, 2001

Attending: Larry Schall, Vice President for Facilities and Services
Stu Hain, Director of Facilities Management

What are your projected needs of Crum Woods or other College open space, short and long-term?

In 20-year campus-wide plan — New Science Center, new 150-bed residence hall, and renovation of Parrish. Student dormitory (maybe new or renovated) and expansion of McCabe Library are secondary.

Long-range plan connected to capital campaigns (current one ends 2007). Also expansion of Martin, expansion of Hicks, Arts Center and Computer Center. three-level parking and Science Building at rugby field. Pressure to expand dining hall.

Thought is to have an all-purpose athletic field to relieve demands on Field House during winter.

Artificial surface, athletic field with lights

Issue is fall and spring seasons for same sport.

Baseball, softball and soccer field on opposite side of creek. Softball possibly can stay where it is.

Football is dropped — no need for field. Plan for athletic fields (Athletics Planning Committee — Athletics Department and Larry Schall) to be completed by December 2001. Will be reviewed by Land-Use Committee, etc.

Conflict — increased enrollment and need for athletic fields.

What are the terms of the lease for the composting site?

5-year term with long notice (1–2 years)

Nether Providence and Swarthmore use composting facility

What are your concerns about use and management of Crum Woods?

Crum Woods is seen as town park.

Partying (breaking of bottles)

Dog use

Have tried to implement leash law

Not enough security to enforce regulations in Crum Woods

Bikes are less of a concern.

Some unauthorized deer hunting (bow probably) — not posted, not enforced

If deer become a problem would need to bring in sharpshooters.

Dams — not clear who owns them; possibly considering removal.

Ruins — pretty much ignored.

SCOTT ARBORETUM — 6 JUNE, 2001

Attending: Andrew Bunting, Curator
Chuck Hinkle, Gardener Supervisor
Jeff Jabco, Director of Grounds, Coordinator of Horticulture
Rhoda Maurer, Plant Records
Claire Sawyers, Director

How is Crum Woods currently managed?

Management is a combination of Facilities staff and Arboretum (primarily volunteers, ±100, 1 or 2 days per week).

Mainly in winter (weather dependent): November — mark Norway maples, December — trail maintenance, erosion control, litter, Norway maple, etc. removal, improvements

Urgent/large needs and stump treatment handled by Facilities during remainder of year.

Not enough effort to accomplish all they want to

100 volunteer assistants — tasks: invasive controls, trail maintenance (water bars), cleanup

Nothing done on opposite side of creek.

Other sources of labor:

(1) Students from Williamson Trade School have been used last 2 years (chainsaw work, etc.); relationship is informal.

(2) Periodic — community cleanup days, mainly trash, some invasives

(3) Student club (Earthlust) — 1–2 cleaning days during '90s

(4) Fire Company — removal of debris from creek (log jams)

View is to restore Crum Woods to native woodland, not as a collection site. Dr. Wister's planting schemes centered around species native to Pennsylvania, native to eastern U.S.A.

Staffing: 8 fulltime Arboretum staff paid from $19 million endowment

13 fulltime on grounds — no mowing and tree work (contracted out)

Jeff Jabco's staff does no mowing or tree work

What level of staff would you like to see committed to managing Crum Woods?

2 to 3 additional staff to maintain Crum Woods with some contractors for restoration (wish list)

Need to have someone in development to help find funding to do restoration.

Need to have someone to continue maintenance after restoration.

Woods used in some programs: walks, Arbor Day planting. Any more would be a function of staffing, not a big part of mission.

What are your concerns about use and management of Crum Woods?

No problems with deer feeding, just buck rubs mainly in the nursery.

Peter Weber — EPA/watershed group, did some analysis of Crum Creek , recommended increasing buffer, stop mowing to bank which they did.

Concern about mountain bike users/rogue trails from town, mainly on campus side of creek

Dogs are less of problem now that there is a leash law (last 1–2 years).

Some vandalism — initials carved into trees

Trash not a big problem — broken bottles, painting trees

Regular walkers will often pick up litter.

Trash cans are scattered at trailheads.

Property is seen as park, which is okay with us.

Trails were signed — within a week they were destroyed. Signs were perceived as an intrusion into "wilderness."

Ruins should remain as place to explore. Some groups have explored cleaning up ruins.

Development (current) has already impacted woods.

Need to make College aware that more input is needed to decision-making (example: Dupont water tower parking lot and tennis court — went through without any consultation, gully created by break in water tower line). Hopes situation will be changed with new Stewardship Committee.

No formal committee process — projects donor-driven with little input to process by Arboretum staff.

Need to define boundary of "sacred ground."

Protocol needed to review any potential impact from new activities — need oversight of construction (impacts go beyond edge of construction).

New chiller plant for Science Building is being put at entrance to Woods.

Need to consider long-term effects of dumping on-site (soil, masonry, metal).

Some local schools use it with some not calling first.

Should build parking garage.

Need mechanism within College to weight management decisions (example: poison-ivy removal). How do you weigh different value systems of stakeholders?

Concerned that momentum will be lost. Need long-term commitment (easement?)

College is uniquely positioned to provide living lab to students. Need to highlight environmental and ecological values of Crum Woods, not just sentimental memories of alumni.

Place easement on at least part of Crum Woods.

Need to hire full-time person to focus on Crum Woods — coordinate all activities. Could be funded from overhead monies.

Crum Woods encompasses a significant percentage of College lands and provides significant environmental, ecological, academic and recreational benefits, yet no one is in charge of management.

Remove composting facility. College provides enough benefit to local communities—economic, recreational — plus the facility fosters the perception that the Woods are a waste area; ecological, aesthetic impacts.

CRUM WOODS VOLUNTEERS — 22 JUNE, 2001

Attending: Astrid Devaney (works in Alumni Office)
Sally Dow (also an Arboretum volunteer)
Walter Dow
Mary Lou Gessel (also an Arboretum volunteer)
Doug Hasbrouck
Geoff Semenuk (works in Alumni Office)
Julie Vrooman (also an Arboretum volunteer)

Background/jobs:

Started in 1973–74 by students, became mostly staff, now includes community; was once part of Arboretum, now own *ad hoc* group.

More formal programs started by students in late 1980s.

Thursday morning volunteers switch to Woods in winter; were organized by the Arboretum; involved with trail water bar cleanout and brush removal.

Lead hikes.

Organize cleanup days — 20 to 30 people, usually from Borough.

Cleaning along creek, from meadow area north

Trash removal

Cutting vines

Also pick up trash as they use Woods.

Why do you do it? — It needs to be done; like to be outside.

What are your concerns about use and management of Crum Woods?

Stream bank erosion, need planting, stormwater from upstream development. Previous administration saw trees in creek as causing erosion and would take them out; current administration sees it as natural

"Lang ditch" (large erosion gully)

Level of use is appropriate, mostly dog walkers.

Trail erosion — need year-round attention, need more water bars.

Lack of coordination/priority from Arboretum, would like to have someone designated to oversee the woods.

Ivy on trees — needs to be removed, use goats with temporary fence?

Trash is mainly from town kids.

Concerned about safety if kids begin use woods.

Need plantings, especially along Meadow.

Mountain bikes are a concern.

Cross-country team does not use trails any longer for running due to lack of maintenance.

What would you like to see happen in the Crum Woods?

Education (especially kids) and use

More control of invasives

Staff dedicated to Woods

Move trash cans to Crumhenge where people congregate.

Increase Arboretum staff — but lack of space for a new person.

Year-round use of volunteers

Such a special place — should be used more.

Staff person that unites Biology Department, the Arboretum and grounds crew

Maintain integrity of what's left; don't do the development across Creek.

Should encourage more kids to use Woods, introduce them through cleanup projects.

Conservation easement

Use Woods for education; make a better case for stand against development plans.

Would like to see footbridge across creek.

More use of Woods on west side of creek

Remove concrete and asphalt from wetlands (restore with Growing Greener grant).

Make Woods as much a showplace as the formal Arboretum.

Be on vanguard of environmental protection in the face of development pressure.

Make case of Woods as important part of reputation of College.

Formally integrate into College academically.

Are there examples of other colleges using surrounding natural areas?

Microcosm of conflict between human needs and viability of natural areas

Can the College expand toward the town, not into Woods?

ADJOINING NEIGHBORS — 11 JULY, 2001

Attending: Carl and Joyce Clauss, 402 Crumwald Lane, Wallingford
Brinton and Eleanor Medford, 403 Crumwald Lane, Wallingford
Dr. Andrea Moran, 520 Plush Mill Road (just purchased), Wallingford
Leslie Price, 6112 Elm Avenue, Swarthmore
Dr. Tom Stephenson, 737 Harvard Avenue, Swarthmore
Betsy Wray, 620 Hillborn Avenue, Swarthmore
Debby Yoder, 419 Roger Lane, Wallingford

How do you currently use the Crum Woods?

Walking, collecting firewood, fishing

Shields home from the Blue Route

Biggest asset to their homes

Buying house because of woods

What are your concerns about use and management of Crum Woods?

Teenagers, parties, especially in relation to potential new athletic fields and bridge (creating access)

Will there be parking with new athletic fields?

Access from bikeway

Keep natural.

Increase in number of deer, especially since Blue Route was put in

Litter doesn't seem to be a problem.

Creek water levels — mostly low, then floods, used to be more constant.

Maintenance has been better since Scott has focused its efforts, but would like more. (How can funding be increased?)

445 Rogers Lane (owned by College) not taken care of like it used to be.

What would you like to see happen in the Crum Woods?

Link more paths (bridge).

In favor of scheduled bowhunting.

Leave as wild as possible.

MUNICIPAL ENVIRONMENTAL ADVISORY COMMITTEE (E.A.C.) CHAIRS — 11 JULY, 2001

Attending: Paul Horna (Springfield Township)
Jon Sutton (Nether Providence Township)
Jim Taylor (Borough of Swarthmore)

What are your concerns about use and management of Crum Woods?

Concerned regarding Water Company development and development of College land.

High demand for ball fields

Connection to Nether Providence side might decrease use of railroad trestle.

Concerned that moving fields across stream will increase development on College land.

Storm water concerns

What would you like to see happen in the Crum Woods?

Deal with stormwater/erosion through recharge basins.

Preservation of open space — concerned about development at the College; Borough relies heavily on the Woods as open space.

Would not like to see restricted use.

Would like to see more natural areas — too much manicured area.

Woods provide excellent buffer to Crum Creek.

Would like to increase public recreational use within reason.

Focus on aesthetics (wildflowers) at high public-use areas (education).

Determine areas that can take higher use.

Develop link between Crum Woods and Smedley Park at Baltimore Pike.

Appendix E. Organismal Diversity in the Crum Woods

Sources for species documentation are: [1]Cushman and Lowe (1971); [2]Pennsylvania Fish and Boat Commission (1999; unpubl. data collected in Crum Creek 8.4 miles [13 km] upstream and 2.7 miles [4.3 km] downstream from Swarthmore College land); [3]Pennsylvania Department of Environmental Protection (2000; unpubl. data collected in Crum Creek 7.6 miles [12 km] upstream); [4]U.S. Geological Survey, unpubl. data; [5]Williams et al. 1999 (see Appendix C); [6]collection in 1962 by L. Berkeley deposited in Swarthmore College Herbarium; [7]Swarthmore College Herbarium (see Appendix A); [8]observation in 2000–2002 by R. Latham (see Appendix A). Estimated ranges of probable species numbers are derived from Hassinger et al. (1998) and Latham (2002) except where marked: [9]Roger K. Conant, pers. comm. A blank cell indicates that no relevant data were found. The list of eukaryote taxa other than fungi, animals and green plants does not necessarily include all of the groups that may be present.

major taxon	lineage	documented presence / number of species	estimated total species
ARCHAEBACTERIA	**domain Archaea**		
"TRUE" BACTERIA	**domain Bacteria**		
EUKARYOTES	**domain Eukarya**		
miscellaneous eukaryotes			
ciliates	Alveolata: Ciliophora		50–100
dinoflagellates	Alveolata: Dinophyceae		5–10
cryptomonads	Cryptophyta		
diplomonads	Diplomonadida		
euglenids	Euglenozoa: Euglenida		
kinetoplasts	Euglenozoa: Kinetoplastida		
foraminifers	Granuloreticulosea: Foraminifera		
amebas	Lobosea		
slime molds	Mycetozoa		10–50
water molds, downy mildews	Oomycetes		

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Appendix E (continued)

major taxon	lineage	documented presence / number of species	estimated total species
EUKARYOTES (continued)			
trichomonads	Parabasalidea: Trichomonadida		
plasmodiophorids	Plasmodiophorida		
diatoms	stramenopiles: Bacillariophyta	present in creek[1]	
golden algae	stramenopiles: Chrysophyceae		
yellow-green algae	stramenopiles: Xanthophyceae		
fungi	**kingdom Fungi**		
ascomycetes	Ascomycota		500–1,000
lichens	Ascomycota in symbiosis with Chlorophyta or Cyanobacteria		50–100
basidiomycetes	Basidiomycota		500–1,000
chytridiomycetes	Chytridiomycota		1–5
zygomycetes	Zygomycota		5–10
animals	**kingdom Metazoa**		
thorny-headed worms	Acanthocephala		1–5
leeches, branchiobdellids	Annelida: Hirudinida	present in creek[2]	5–10
earthworms, tubifex worms	Annelida: Oligochaeta	present in creek[2,3]	5–10
polychaetes	Annelida: Polychaeta		1–5
mites, ticks	Arthropoda: Arachnida: Acari	present in creek[1]	50–100
spiders	Arthropoda: Arachnida: Araneae		50–100
daddy-longlegs	Arthropoda: Arachnida: Opiliones		5–10
pseudoscorpions	Arthropoda: Arachnida: Pseudoscorpiones		1–5
scuds, well shrimps	Arthropoda: Crustacea: Amphipoda	present in creek[2]	1–5

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Sources (superscripts) are identified on first page of Appendix E.

Appendix E (continued)

major taxon	lineage	documented presence / number of species	estimated total species
EUKARYOTES (continued)			
fairy shrimps, water-fleas	Arthropoda: Crustacea: Branchiopoda		5–10
pillbugs, wood-lice	Arthropoda: Crustacea: Isopoda		1–5
crayfishes, crabs, shrimps	Arthropoda: Crustacea: Malacostraca	present in creek[2]	5–10
branchiurans, copepods	Arthropoda: Crustacea: Maxillopoda	present in creek[1]	5–10
mussel shrimps	Arthropoda: Crustacea: Ostracoda		5–10
tongue worms	Arthropoda: Pentastomida		1–5
springtails	Arthropoda: Tracheata: Hexapoda: Collembola		5–10
entotrophs	Arthropoda: Tracheata: Hexapoda: Diplura		1–5
bristletails	Arthropoda: Tracheata: Hexapoda: Insecta: Archaeognatha		1–5
cockroaches	Arthropoda: Tracheata: Hexapoda: Insecta: Blattaria		1–5
beetles	Arthropoda: Tracheata: Hexapoda: Insecta: Coleoptera	present in creek[1,2,3]	500–1,000
earwigs	Arthropoda: Tracheata: Hexapoda: Insecta: Dermaptera		1–5
"true" flies	Arthropoda: Tracheata: Hexapoda: Insecta: Diptera	present in creek[1,2,3]	100–500
mayflies	Arthropoda: Tracheata: Hexapoda: Insecta: Ephemeroptera	present in creek[1,2,3]	10–50
water-striders, wheel bugs, spittlebugs, cicadas, plant bugs, leafhoppers	Arthropoda: Tracheata: Hexapoda: Insecta: Hemiptera: Euhemiptera	present in creek[1,2]	50–100
whiteflies, aphids, mealybugs, scales, plant lice	Arthropoda: Tracheata: Hexapoda: Insecta: Hemiptera: Sternorrhyncha		50–100
sawflies, wasps, bees, ants	Arthropoda: Tracheata: Hexapoda: Insecta: Hymenoptera		100–500
termites	Arthropoda: Tracheata: Hexapoda: Insecta: Isoptera		1–5

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Sources (superscripts) are identified on first page of Appendix E.

Appendix E (continued)

major taxon	lineage	documented presence / number of species	estimated total species
EUKARYOTES (continued)			
butterflies, moths, skippers	Arthropoda: Tracheata: Hexapoda: Insecta: Lepidoptera		100–500
mantids	Arthropoda: Tracheata: Hexapoda: Insecta: Mantodea		1–5
scorpionflies, hangingflies	Arthropoda: Tracheata: Hexapoda: Insecta: Mecoptera		1–5
dobsonflies, fishflies, alderflies	Arthropoda: Tracheata: Hexapoda: Insecta: Megaloptera	present in creek[2]	1–5
lacewings, ant-lions	Arthropoda: Tracheata: Hexapoda: Insecta: Neuroptera		2–10
dragonflies, damselflies	Arthropoda: Tracheata: Hexapoda: Insecta: Odonata	present in creek[1,2]	10–50
grasshoppers, crickets, katydids	Arthropoda: Tracheata: Hexapoda: Insecta: Orthoptera		2–10
walking-sticks	Arthropoda: Tracheata: Hexapoda: Insecta: Phasmatodea		1–5
lice	Arthropoda: Tracheata: Hexapoda: Insecta: Phthiraptera		2–10
stoneflies	Arthropoda: Tracheata: Hexapoda: Insecta: Plecoptera	present in creek[2,3]	10–50
booklice, barklice	Arthropoda: Tracheata: Hexapoda: Insecta: Psocoptera		2–10
fleas	Arthropoda: Tracheata: Hexapoda: Insecta: Siphonaptera		1–5
twisted-wing insects	Arthropoda: Tracheata: Hexapoda: Insecta: Strepsiptera		1–5
thrips	Arthropoda: Tracheata: Hexapoda: Insecta: Thysanoptera		2–10
silverfish, firebrats	Arthropoda: Tracheata: Hexapoda: Insecta: Thysanura		1–5
caddisflies	Arthropoda: Tracheata: Hexapoda: Insecta: Trichoptera	present in creek[1,2,3]	20–50
proturans	Arthropoda: Tracheata: Hexapoda: Protura		1–5
centipedes	Arthropoda: Tracheata: Myriapoda: Chilopoda		2–10
pauropods	Arthropoda: Tracheata: Myriapoda: Pauropoda		1–5
symphylans	Arthropoda: Tracheata: Myriapoda: Symphyla		1–5
bryozoans	Bryozoa		1–5
ray-finned fishes	Chordata: Vertebrata: Actinopterygii	22[2]	20–35

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Sources (superscripts) are identified on first page of Appendix E.

Appendix E (continued)

major taxon	lineage	documented presence / number of species	estimated total species
EUKARYOTES (continued)			
amphibians	Chordata: Vertebrata: Amphibia		10–15[9]
birds (total, including migrants, accidentals)	Chordata: Vertebrata: Aves	149[5]	150–180
birds (breeding in the Crum Woods)	Chordata: Vertebrata: Aves	61[5]	60–75
mammals	Chordata: Vertebrata: Mammalia		20–35
jawless vertebrates (lampreys)	Chordata: Vertebrata: Petromyzontiformes		0–1
snakes, lizards	Chordata: Vertebrata: Squamata		4–8[9]
turtles	Chordata: Vertebrata: Testudines		4–6[9]
hydras, freshwater "jellyfish"	Cnidaria: Hydrozoa		1–5
gastrotrichs	Gastrotricha	present in creek[1]	1–5
fingernail clams	Mollusca: Bivalvia: Heteroconchia	present in creek[3]	2–10
freshwater mussels	Mollusca: Bivalvia: Palaeoheterodonta		2–10
freshwater snails	Mollusca: Gastropoda: Pulmonata: Basommatophora	present in creek[1,2]	5–10
terrestrial snails, slugs	Mollusca: Gastropoda: Pulmonata: Stylommatophora		5–10
millipedes	Myriapoda: Diplopoda		5–10
sporozoans	Myxozoa		1–2
roundworms	Nematoda	present in creek[1]	10–100
horsehair worms	Nematomorpha		1–5
tapeworms	Platyhelminthes: Cestoda		1–5
flukes	Platyhelminthes: Trematoda		1–5
flatworms	Platyhelminthes: Turbellaria	present in creek[1]	2–10

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Sources (superscripts) are identified on first page of Appendix E.

Appendix E (continued)

major taxon	lineage	documented presence / number of species	estimated total species
EUKARYOTES (continued)			
sponges	Porifera: Spongillidae	present in creek[2]	1–5
rotifers	Rotifera		2–10
water-bears	Tardigrada		1–5
green plants	**kingdom Viridiplantae**		
green algae	Chlorophyta	present in creek[2]	
stoneworts	Streptophyta: Characeae		
pond algae	Streptophyta: Coleochaetaceae		
hornworts	Streptophyta: Embryophyta: Anthocerotophyta		
mosses	Streptophyta: Embryophyta: Bryophyta	16[6]	40–60
liverworts	Streptophyta: Embryophyta: Marchantiophyta		10–20
conifers	Streptophyta: Embryophyta: Tracheophyta: Coniferophyta	7[7,8]	10–15
horsetails	Streptophyta: Embryophyta: Tracheophyta: Equisetophyta		1–4
ferns	Streptophyta: Embryophyta: Tracheophyta: Filicophyta	5[7,8]	10–20
quillworts, spikemosses, clubmosses	Streptophyta: Embryophyta: Tracheophyta: Lycopodiophyta	1[8]	2–10
flowering plants	Streptophyta: Embryophyta: Tracheophyta: Magnoliophyta	308[7,8]	400–500
conjugating green algae	Streptophyta: Mesostigmatophyceae		
desmids	Streptophyta: Zygnemophyceae		

Sources (superscripts) are identified on first page of Appendix E.

Appendix F. Vascular Plant Species Documented in the Crum Woods

Vascular plant species documented in the Crum Woods, excluding landscaped areas around houses and arboretum collection areas. Appendix includes 329 entries, estimated to represent perhaps 60 to 80% of the actual vascular flora of the Crum Woods. Nomenclature follows Rhoads and Block 2000. Identifications with question marks are uncertain.

Status codes:

INT INV	introduced species considered invasive or potentially invasive (39 species)
INT	other introduced species (56)
PA	species of special concern in Pennsylvania (4)
EXTP?	probably extirpated in the Crum Woods (2)
PL/PL?	planted/probably planted (5)

Source codes:

H	specimen in the Swarthmore College Department of Biology Herbarium
L	recorded by Roger Latham in the course of surveying plant communities

		status	source
boxelder	*Acer negundo*		H, L
Japanese maple	*Acer palmatum*	INT	L
Norway maple	*Acer platanoides*	INT INV	L
sycamore maple	*Acer pseudoplatanus*	INT	L
red maple	*Acer rubrum*		H, L
silver maple	*Acer saccharinum*		L
sugar maple	*Acer saccharum*		H, L
common yarrow	*Achillea millefolium*		H
maidenhair fern	*Adiantum pedatum*		H
goutweed	*Aegopodium podagraria*	INT INV	L
autumn bent	*Agrostis perennans*		H
tree-of-heaven	*Ailanthus altissima*	INT INV	L
akebia	*Akebia quinata*	INT INV	L
northern water-plantain	*Alisma plantago-aquatica*		H
garlic-mustard	*Alliaria petiolata*	INT INV	L
wild onion	*Allium (canadense?)*		L
smooth alder	*Alnus serrulata*		L
green amaranth	*Amaranthus retroflexus*		H
common ragweed	*Ambrosia artemisiifolia*		L

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Appendix F (continued)

		status	source
porcelainberry	*Ampelopsis brevipedunculata*	INT INV	L
wood anemone	*Anemone quinquefolia*		H
Indian-hemp	*Apocynum cannabinum*		L
mouse-ear cress	*Arabidopsis thaliana*	INT	H
spreading rock-cress	*Arabis patens*		H
Japanese angelica-tree	*Aralia elata*	INT INV	L
wild sarsaparilla	*Aralia nudicaulis*		H, L
common burdock	*Arctium minus*	INT	L
jack-in-the-pulpit	*Arisaema triphyllum*		H, L
sweet wormwood	*Artemisia annua*	INT	L
wild-ginger	*Asarum canadense*		H, L
pawpaw	*Asimina triloba*		L
blue wood aster	*Aster cordifolius* ssp. *cordifolius (=Symphyotrichum cordifolium* ssp. *cordifolium)*		H
smooth heart-leaved aster	*Aster cordifolius* ssp. *laevigatus (=Symphyotrichum cordifolium* ssp. *laevigatum)*		H
white wood aster	*Aster divaricatus (=Eurybia divaricata)*		H, L
calico aster	*Aster lateriflorus (=Symphyotrichum lateriflorum)*		H
simple aster	*Aster lanceolatus* ssp. *simplex (=Symphyotrichum lanceolatum* ssp. *simplex)*		L
New England aster	*Aster novae-angliae (=Symphyotrichum novae-angliae)*		H
New York aster	*Aster novae-belgii (=Symphyotrichum novae-belgii)*	PA threat-ened	H
late purple aster	*Aster phlogifolius (=Symphyotrichum phlogifolium)*		H
heath aster	*Aster pilosus var. demotus (=Symphyotrichum pilosum var. demotum)*		H
heath aster	*Aster pilosus var. pilosus (=Symphyotrichum pilosum var. pilosum)*		H
purple-stemmed aster	*Aster puniceus (=Symphyotrichum puniceum)*		H, L
clasping heart-leaved aster	*Aster undulatus (=Symphyotrichum undulatum)*		H
lady fern	*Athyrium filix-foemina*		L
wild indigo	*Baptisia tinctoria*		H
common winter-cress	*Barbarea vulgaris*		H

(continued on next page)

Appendix F (continued)

		status	source
Japanese barberry	*Berberis thunbergii*	INT	H, L
sweet birch	*Betula lenta*		L
false nettle	*Boehmeria cylindrica*		L
corn gromwell	*Buglossoides arvense*	INT	H
reed bluejoint	*Calamagrostis cinnoides*		H
Carolina allspice	*Calycanthus floridus var. laevigatus*		H
bitter-cress	*Cardamine bulbosa*		H
cutleaf toothwort	*Cardamine concatenata*		H, L
hairy bitter-cress	*Cardamine hirsuta*	INT	H
sedge	*Carex aggregata*		H
sedge	*Carex amphibola*		H
sedge	*Carex annectans*		H
sedge	*Carex bushii*		H
sedge	*Carex gracillima*		H
sedge	*Carex grisea*		H
sedge	*Carex hirta*	INT	H
sedge	*Carex hirtifolia*		H
sedge	*Carex laxiflora*		H
sedge	*Carex scoparia*		H
sedge	*Carex hirsutella*		H
sedge	*Carex vestita*		H
sedge	*Carex virescens*		H
American hornbeam	*Carpinus caroliniana*		L
bitternut hickory	*Carya cordiformis*		L
mockernut hickory	*Carya tomentosa*		L
American chestnut	*Castanea dentata*		L
Chinese chestnut	*Castanea mollissima*	INT	L
blue cohosh	*Caulophyllum thalictroides*		L
Asiatic bittersweet	*Celastrus orbiculatus*	INT INV	L
black knapweed	*Centaurea nigra*	INT	H
nodding chickweed	*Cerastium nutans*		H
turtlehead	*Chelone glabra*		H
Mexican-tea	*Chenopodium ambrosioides*	INT	H
spotted wintergreen	*Chimaphila maculata*		L

(continued on next page)

Appendix F (continued)

		status	source
fringetree	*Chionanthus virginicus*		L
ox-eye daisy	*Chrysanthemum leucanthemum*	INT	H
black snakeroot	*Cimicifuga racemosa*		L
wood reedgrass	*Cinna arundinaceae*		H
Canada thistle	*Cirsium arvense*	INT INV	L
spring-beauty	*Claytonia virginica*		H, L
wild basil	*Clinopodium vulgare*	INT	H
garden larkspur	*Consolida ambigua*	INT	H
alternate-leaf dogwood	*Cornus alternifolia*		L
silky dogwood	*Cornus amomum*		L
flowering dogwood	*Cornus florida*		H, L
crownvetch	*Coronilla varia*	INT INV	L
American hazel	*Corylus americana*		L
filbert	*Corylus avellana*	INT	L
hawthorn	*Crataegus* sp.		L
honewort	*Cryptotaenia canadensis*		L
buttonbush dodder	*Cuscuta cephalanthii*	PA rare (status undetermined)	H
dodder	*Cuscuta* sp.		L
false-nutsedge	*Cyperus strigosus*		H
large yellow lady's-slipper	*Cypridepium calceolus var. pubescens*	EXTP?	H
tick-trefoil	*Desmodium nudiflorum*		H
Dutchman's-breeches	*Dicentra cucullaria*		H, L
northern crabgrass	*Digitaria sarguinalis*	INT	H
marginal woodfern	*Dryopteris marginalis*		L
Indian strawberry	*Duchesnea indica*	INT INV	L
wild-rye	*Elymus villosus*		H
Virginia wild-rye	*Elymus virginicus*		H
beechdrops	*Epifagus virginiana*		H, L
trailing arbutus	*Epigaea repens*		H, L
stink grass	*Eragrostis cilianensis*	INT	H
robin's-plantain	*Erigeron puchellus*		H

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Appendix F (continued)

		status	source
trout lily	*Erythronium americanum*		H, L
burning-bush	*Euonymus alatus*	INT INV	L
wintercreeper	*Euonymus fortunei*	INT	L
joe-pye-weed	*Eupatorium (fistulosum? maculatum? purpureum?)*		L
white snakeroot	*Eupatorium rugosum*		L
American beech	*Fagus grandifolia*		L
fescue	*Festuca elatior*	INT	H
sheep fescue	*Festuca ovina*	INT	H
fescue	*Festuca* spp.	INT	L
white ash	*Fraxinus americana*		L
green ash, red ash	*Fraxinus pennsylvanica*		L
showy orchis	*Galearis spectabilis*		H
bedstraw	*Galium aparine*		H, L
wood geranium	*Geranium maculatum*		H
gill-over-the-ground	*Glechoma hederacea*	INT INV	L
honeylocust	*Gleditsia triacanthos*		L
witch-hazel	*Hamamelis virginiana*		L
American pennyroyal	*Hedeoma pulegioides*		H
English ivy	*Hedera helix*	INT INV	H, L
Quaker-ladies	*Hedyotis caerulea*		H
southern sneezeweed	*Helenium flexuosum*	INT	H
thin-leaved sunflower	*Helianthus decapetalus*		H
Jerusalem artichoke	*Helianthus tuberosus*		L
liverleaf	*Hepatica nobilis var. obtusa*		H
cow-parsnip	*Heracleum lanatum*		L
Japanese hops	*Humulus japonicus*	INT INV	L
shining clubmoss	*Huperzia lucidula*		L
Virginia waterleaf	*Hydrophyllum virginianum*		L
Japanese holly	*Ilex crenata*	INT	L
mountain winterberry	*Ilex montana*		L
American holly	*Ilex opaca*		L
common winterberry	*Ilex verticillata*		L
spotted touch-me-not	*Impatiens capensis*		H, L
northern blue flag	*Iris (versicolor?)*		L

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Appendix F (continued)

		status	source
black walnut	*Juglans nigra*		L
mountain-laurel	*Kalmia latifolia*		L
henbit	*Lamium amplexicaule*	INT	H
wood nettle	*Laportea canadensis*		H, L
European larch or Japanese larch	*Larix (decidua? kaempferi?)*	INT	L
rice cutgrass	*Leersia oryzoides*		H
cutgrass	*Leersia virginica*		H
bush-clover	*Lespedeza intermedia*		H
border privet	*Ligustrum obtusifolium*	INT INV	L
spicebush	*Lindera benzoin*		L
sweetgum	*Liquidambar styraciflua*		L
tuliptree	*Liriodendron tulipifera*		L
great lobelia	*Lobelia siphilitica*		H
perennial ryegrass	*Lolium perenne*	INT	H
Japanese honeysuckle	*Lonicera japonica*	INT INV	H, L
Amur honeysuckle	*Lonicera maackii*	INT INV	L
common wood-rush	*Luzula echinata*		L
fringed loosestrife	*Lysimachia ciliatum*		H
purple loosestrife	*Lythrum salicaria*	INT INV	L
cucumbertree	*Magnolia acuminata*		L
bigleaf magnolia	*Magnolia macrophylla*	PL?	L
umbrella magnolia	*Magnolia tripetala*		L
sweetbay	*Magnolia virginiana*	PL?	L
creeping Oregon-grape	*Mahonia (repens?)*	INT	L
sweet crab apple	*Malus (coronaria?)*		L
showy crab apple	*Malus (floribunda?)*	INT	L
Indian cucumber-root	*Medeola virginiana*		H
peppermint	*Mentha aquatica x spicata*	INT	H
Virginia bluebells	*Mertensia virginica*		H, L
Japanese stilt grass	*Microstegium vimineum*	INT INV	L
millet grass	*Milium effusum*	INT	H
Japanese plumegrass	*Miscanthus sinensis*	INT INV	L
partridgeberry	*Mitchella repens*		H, L
bishop's-cap	*Mitella diphylla*		H

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Appendix F (continued)

		status	source
Indian-pipe	*Monotropa uniflora*		H, L
satin grass	*Muhlenbergia mexicana*		H
daffodil	*Narcissus pseudonarcissus*	INT INV	L
catnip	*Nepeta cataria*	INT	H
blackgum	*Nyssa sylvatica*		L
pennywort	*Obolaria virginica*		H
sensitive fern	*Onoclea sensibilis*		L
sweet-cicely	*Osmorhiza claytonii*		H
anise-root	*Osmorhiza longistylis*		H
hop-hornbeam	*Ostrya virginiana*		L
pachysandra, Japanese spurge	*Pachysandra terminalis*	INT INV	L
dwarf ginseng	*Panax trifolius*		H, L
deer-tongue	*Panicum clandestinum*		L
panic-grass	*Panicum commutatum*		H
Heller's witch-grass	*Panicum oligosanthes*		H
Virginia creeper	*Parthenocissus quinquefolia*		L
field beadgrass	*Paspalum laeve*		H
royal paulownia	*Paulownia tomentosa*	INT INV	L
forest lousewort	*Pedicularis canadensis*		H
perilla	*Perilla frutescens*	INT	L
reed canary grass	*Phalaris arundinacea*		H, L
Amur corktree	*Phellodendron amurense*	INT INV	L
mock-orange	*Philadelphus* sp.	INT INV	L
blue phlox	*Phlox divaricata* var. *laphamii*	INT	L
phragmites, common reed	*Phragmites australis*	INT INV	L
ninebark	*Physocarpus opulifolius*		L
pokeweed	*Phytolacca americana*		L
Norway spruce	*Picea abies*	INT	L
clearweed	*Pilea pumila*		L
red pine	*Pinus resinosa*	PL	L
white pine	*Pinus strobus*	PL?	L
American sycamore	*Platanus occidentalis*		L
annual bluegrass	*Poa annua*	INT	H

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Appendix F (continued)

		status	source
bluegrass	*Poa cuspidata*		H
woodland bluegrass	*Poa sylvestris*		H
may-apple	*Podophyllum peltatum*		H, L
jacob's-ladder	*Polemonium reptans*		H, L
Solomon's-seal	*Polygonatum biflorum var. commutatum*		H
black bindweed	*Polygonum convolvulus*	INT INV	L
Japanese knotweed	*Polygonum cuspidatum*	INT INV	L
mile-a-minute	*Polygonum perfoliatum*	INT INV	L
lady's-thumb	*Polygonum persicaria*	INT	L
dotted smartweed	*Polygonum punctatum*		H
jumpseed	*Polygonum virginianum*		L
Christmas fern	*Polystichum acrostichoides*		L
balsam poplar	*Populus balsamifera*		L
cinquefoil	*Potentilla canadensis*		H
sweet cherry, bird cherry	*Prunus avium*	INT INV	L
black cherry	*Prunus serotina*		L
hybrid cherry	*Prunus* sp.	INT	L
garden bamboo	*(Pseudosasa? japonica?)*	INT INV	L
white oak	*Quercus alba*		L
scarlet oak	*Quercus coccinea*		L
southern red oak	*Quercus falcata*	PA endang-ered	L
chestnut oak	*Quercus montana (=Q. prinus)*		L
pin oak	*Quercus palustris*		L
northern red oak	*Quercus rubra*		L
black oak	*Quercus velutina*		L
small-flowered buttercup	*Ranunculus abortivus*		H
bulbous buttercup	*Ranunculus bulbosus*	INT	H
lesser celandine	*Ranunculus ficaria*	INT INV	L
hairy buttercup	*Ranunculus hispidus*		H
rosebay rhododendron	*Rhododendron maximum*		L
pinxter-flower	*Rhododendron periclymenoides*		L

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Appendix F (continued)

		status	source
jetbead	*Rhodotypos scandens*	INT INV	L
black locust	*Robinia pseudoacacia*	INT INV	L
multiflora rose	*Rosa multiflora*	INT INV	L
blackberry	*Rubus allegheniensis*		L
black raspberry	*Rubus occidentalis*		L
blackberry	*Rubus pensilvanicus*		L
wineberry	*Rubus phoenicolasius*	INT	L
cutleaf coneflower	*Rudbeckia laciniata*		H
tall dock	*Rumex (altissimus?)*		L
white willow	*Salix (alba?)*	INT	L
black willow	*Salix nigra*		L
common elderberry	*Sambucus racemosa*		L
bloodroot	*Sanguinaria canadense*		H, L
Canadian sanicle	*Sanicula canadensis*		H
sassafras	*Sassafras albidum*		L
early saxifrage	*Saxifraga virginiensis*		H
little bluestem	*Schizachyrium scoparium*		L
giant foxtail	*Setaria faberi*	INT	L
yellow foxtail	*Setaria pumila*	INT	L
green foxtail	*Setaria viridis*	INT	H
red campion	*Silene dioica*	INT	H
cup flower	*Silphium perfoliatum*	INT	L
Solomon's-plume	*Smilacina racemosa*		L
carrion-flower	*Smilax herbacea*		H
greenbrier	*Smilax rotundifolia*		L
silver-rod	*Solidago bicolor*		H
blue-stem goldenrod	*Solidago caesia*		H
Canada goldenrod	*Solidago canadensis*		H
zigzag goldenrod	*Solidago* flexicaulis		H, L
wrinkle-leaf goldenrod	*Solidago rugosa*		H
goldenrod	*Solidago* spp.		L
Indian grass	*Sorghastrum nutans*		L
bladdernut	*Staphylea trifolia*		L
skunk-cabbage	*Symplocarpos foetidus*		H, L

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Appendix F (continued)

		status	source
sapphire-berry	*Symplocos paniculata*	INT INV	L
dandelion	*Taraxacum offininale*	INT	H
American yew	*Taxus canadensis*		L
Japanese yew	*Taxus cuspidata*	INT	L
rue-anemone	*Thalictrum thalictroides*		H
New York fern	*Thelypteris noveboracensis*		L
foamflower	*Tiarella cordifolia*		L
basswood	*Tilia americana*		H, L
poison-ivy	*Toxicodendron radicans (=Rhus r.)*		H, L
spiderwort	*Tradescantia virginiana*		H
purpletop	*Tridens flavus*		L
hop-clover	*Trifolium dubium*	INT	H
red trillium	*Trillium erectum*		L
white trillium	*Trillium grandiflorum*		L
toadshade	*Trillium sessile*	INT	L
eastern hemlock	*Tsuga canadensis*		L
American elm	*Ulmus americana*		L
slippery elm	*Ulmus rubra*		L
common nettle	*Urtica dioica*		L
bellwort	*Uvularia sessilifolia*		H, L
lowbush blueberry	*Vaccinium pallidum*		L
purpletop vervain	*Verbena bonariensis*	INT	L
white vervain	*Verbena urticifolia*		L
tawny ironweed	*Vernonia glauca*	PA endang-ered	H
corn speedwell	*Veronica arvensis*	INT	H
bird's-eye speedwell	*Veronica (persica?)*	INT	L
thyme-leaved speedwell	*Veronica serpyllifolia*	INT	H
culver's-root	*Veronicastrum virginicum*		H
maple-leaf viburnum	*Viburnum acerifolium*		H, L
southern arrowwood	*Viburnum dentatum*		L
linden viburnum	*Viburnum dilatatum*	INT INV	L
hobble-bush	*Viburnum lantanoides*	EXTP?	H
doublefile viburnum	*Viburnum plicatum*	INT INV	H, L

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Appendix F (continued)

		status	source
blackhaw	*Viburnum prunifolium*		H, L
rusty blackhaw	*Viburnum rufidulum*	PL?	H
Siebold viburnum	*Viburnum sieboldii*	INT INV	L
periwinkle	*Vinca minor*	INT INV	H, L
LeConte's violet	*Viola affinis*		H
sweet white violet	*Viola blanda*		H
American dog violet	*Viola conspersa*		H
blue marsh violet	*Viola cucullata*		H
smooth yellow violet	*Viola eriocarpa*		H, L
halberd-leaved yellow violet	*Viola hastata*	INT	H
southern wood violet	*Viola hirsutula*		H
English violet	*Viola odorata*	INT	H
birdfoot violet	*Viola pedata*		H
round-leaved violet	*Viola rotundifolia*		L
round-leaved violet	*Viola rotundifolia*		H
ovate-leaved violet	*Viola sagittata var. ovata*		H
common blue violet	*Viola sororia*		H, L
fox grape	*Vitis labrusca*		L
frost grape	*Vitis (riparia? vulpina?)*		L
summer grape	*Vitis aestivalis*		L
Japanese wisteria or Chinese wisteria	*Wisteria (frutescens? sinensis?)*	INT INV	L
golden-alexanders	Zizia aptera		H

Appendix G. Bird Species in the Crum Woods

Bird species documented in the Crum Woods, including planted grounds and woods on both sides of Crum Creek, comprise 149 species. Names in **boldface**: species observed to have declined in the last 20 years in the Crum Woods (J. Williams, personal communication). Seasons: spring, March-May; summer, June-August; fall, September-November; winter, December-February. Nomenclature and list sequence follow A.O.U. Checklist (7th edition, 1998). Status and abundance data compiled by Williams et al (1999).

Status codes:

YR	year-round resident
SR	summer resident
*	has been observed nesting on campus (61 species)
WR	winter resident
M	migrant, passes through in spring and fall
V	visitor, occasionally seen or heard
WV	occasionally seen but only in winter

Abundance codes:

a	abundant: always seen in proper habitat and season
c	common: usually seen in proper habitat and season
u	uncommon: seen infrequently
r	rare: seen not more than once or twice per year

	status	spring	summer	fall	winter
SEABIRDS					
double-crested cormorant	V	r			
BITTERNS, HERONS					
American bittern†	M	r			
great blue heron†	M	r		r	
green heron	M	r		r	
VULTURES					
black vulture	V	r			
turkey vulture	YR	c	c	c	c
GEESE, DUCKS					
Canada goose	YR	c	u	u	u
wood duck	SR*	c	c	u	
mallard	YR*	c	c	u	u

(continued on next page)

*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix G (continued)

	status	spring	summer	fall	winter
HAWKS, FALCONS					
osprey†	YR	r	r	r	r
bald eagle†	YR	u	r	r	r
northern harrier†	WR	r		r	r
sharp-shinned hawk	WV	c		c	c
Cooper's hawk	WV	u		u	u
northern goshawk†	WV				r
red-shouldered hawk	WV				r
broad-winged hawk	M	c		c	
red-tailed hawk	YR*	c	c	c	c
American kestrel	YR	r	r	r	r
merlin	WV				r
peregrine falcon†	WV				r
PHEASANTS, QUAILS					
ring-necked pheasant	YR	r	r	r	r
northern bobwhite†	YR	r	r		
SHOREBIRDS					
killdeer	YR*	u	r		
yellowlegs spp.	M	r		r	
solitary sandpiper	M	r		r	
spotted sandpiper	M	c		r	
common snipe†	M/SR	r	r	r	
American woodcock‡	M/SR	r	r	r	
GULLS					
ring-billed gull	YR	c	c	c	c
herring gull	YR	u	u	u	u
DOVES, CUCKOOS					
rock dove	YR*	a	a	a	a
mourning dove	YR*	a	a	a	a
black-billed cuckoo	SR	r			
yellow-billed cuckoo	SR*	u	u		

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*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix G (continued)

	status	spring	summer	fall	winter
OWLS, NIGHTHAWKS					
eastern screech-owl	YR*	u	u	u	u
great horned owl	YR*	c	c	c	c
barred owl	V	u	u	u	u
long-eared owl†	WV				r
common nighthawk	SR	u	u	c	
SWIFTS, HUMMINGBIRDS, KINGFISHERS					
chimney swift	SR*	a	a		
ruby-throated hummingbird	SR*	c	c		
belted kingfisher	SR*	c	c		
WOODPECKERS					
red-bellied woodpecker	YR*	a	a	a	a
yellow-bellied sapsucker	M	u		u	u
downy woodpecker	YR*	c	c	c	c
hairy woodpecker	YR*	c	c	c	c
northern flicker	YR*	a	a	a	a
pileated woodpecker	YR*	u	u	u	u
FLYCATCHERS					
eastern wood-pewee	M/SR*	c	c		
Acadian flycatcher	M/SR*	u	u		
eastern phoebe	M/SR*	c	c		
great crested flycatcher	M/SR*	c	c		
eastern kingbird	M/SR*	c	c		
VIREOS					
white-eyed vireo	SR*	c	c		
yellow-throated vireo	M/SR	u		u	
blue-headed vireo	M	c		u	
warbling vireo	M/SR*	u	u		
Philadelphia vireo	M	r		r	
red-eyed vireo	M/SR*	c	c		

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*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix G (continued)

	status	spring	summer	fall	winter
JAYS, CROWS					
blue jay	YR*	a	a	a	a
American crow	YR*	a	a	a	a
fish crow	YR	c	r	r	c
SWALLOWS					
tree swallow	M/SR*	c	c		
northern rough-winged swallow	M/SR *	c	c		
barn swallow	M/SR*	c	c		
CHICKADEES, TITMICE					
Carolina chickadee	YR*	a	a	a	a
black-capped chickadee	WR				u
tufted titmouse	YR*	a	a	a	a
NUTHATCHES, CREEPERS					
red-breasted nuthatch	WR	u			u
white-breasted nuthatch	YR*	a	a	a	a
brown creeper	YR*	u	u	u	u
WRENS					
Carolina wren	YR*	a	a	a	a
house wren	M/SR*	a	a		
winter wren	M/WR	u		r	r
kinglets, gnatcatchers					
golden-crowned kinglet	M/WR	c		c	u
ruby-crowned kinglet	M	c		c	
blue-gray gnatcatcher	M/SR*	c	c		
THRUSHES AND MIMIC THRUSHES					
veery	M/SR*	c	c		
Bicknell's thrush‡	M	r			
Swainson's thrush†	M	c		c	
hermit thrush	M	c		c	
wood thrush‡	M/SR*	c	c		
American robin	YR*	a	a	a	c

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*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix G (continued)

	status	spring	summer	fall	winter
THRUSHES AND MIMIC THRUSHES (cont'd.)					
gray catbird	M/SR*	a	a	a	
northern mockingbird	YR*	a	a	a	a
brown thrasher	SR*	u	u		
WAXWINGS, STARLINGS					
European starling	YR*	a	a	a	a
cedar waxwing	YR*	c	c	c	c
WOOD WARBLERS					
blue-winged warbler‡	M/SR*	u	u	r	
Tennessee warbler	M	u		u	
Nashville warbler	M	u		u	
northern parula	M/SR*	c	u	u	
yellow warbler	M/SR*	c	u	u	
chestnut-sided warbler	M	u		u	
magnolia warbler	M	u		u	
Cape May warbler	M	r		r	
black-throated blue warbler	M	c		c	
yellow-rumped warbler	M	a		c	
black-throated green warbler	M	c		c	
blackburnian warbler	M	u		u	
pine warbler	M	u		u	
prairie warbler‡	M	u		u	
palm warbler	M	u		u	
bay-breasted warbler‡	M	u		u	
blackpoll warbler	M	u		u	
black-and-white warbler	M	c		c	
American redstart	M	c		c	
prothonotary warbler†‡	SR	r	r		
worm-eating warbler‡	M/SR	u	u	u	
ovenbird	M/SR*	c	u	u	
northern waterthrush	M	u		u	

(continued on next page)

*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix G (continued)

	status	spring	summer	fall	winter
WOOD WARBLERS (cont'd.)					
Louisiana waterthrush	M/SR	r		r	
Kentucky warbler‡	M	r		r	
common yellowthroat	M/SR*	c	c	c	
hooded warbler	M	u		u	
Wilson's warbler	M	r		r	
Canada warbler‡	M	r		r	
TANAGERS, TOWHEES, SPARROWS					
scarlet tanager	M/SR	u	u	u	
eastern towhee	YR*	c	c	c	
American tree sparrow	M	r		r	
chipping sparrow	M/SR*	a	c	c	
savanna sparrow	M	r		r	
fox sparrow	M	r		r	
song sparrow	YR*	a	a	a	r
swamp sparrow	M	r		r	
white-throated sparrow	M/WR	a			a
white-crowned sparrow	M	r		r	
dark-eyed junco	M/WR	a			a
CARDINALS, GROSBEAKS, BUNTINGS					
northern cardinal	YR*	a	a	a	a
rose-breasted grosbeak	M/SR	u	u	u	
blue grosbeak	SR	r	r		
indigo bunting	SR*	u	u	u	
BLACKBIRDS, ORIOLES					
red-winged blackbird	SR	u	u	u	
rusty blackbird‡	WV				r
common grackle	SR*	a	a	a	
brown-headed cowbird	SR*	a	a	a	
orchard oriole	M/SR	u	u	u	
Baltimore oriole	SR*	c	c	c	

(continued on next page)

*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix G (continued)

	status	spring	summer	fall	winter
FINCHES, OLD WORLD SPARROWS					
pine grosbeak	WV				r
purple finch	WV				r
house finch	YR*	a	a	a	a
red crossbill	WV				r
white-winged crossbill	WV				r
common redpoll	WV				r
pine siskin	WV				r
American goldfinch	YR*	a	a	a	a
evening grosbeak	WV				u
house sparrow	YR*	a	a	a	a

*Has been observed nesting on campus (Williams et al. 1999)
†Species of special concern in Pennsylvania (Pennsylvania Natural Diversity Inventory 2001)
‡WatchList species, i.e., those faced with population decline or threats such as habitat loss on breeding and wintering grounds; compiled and updated yearly by Partners in Flight, a coalition of state and federal agencies and non-governmental organizations protecting Western Hemisphere birds (National Audubon Society 2002).

Appendix H. Conservation Easement

A conservation easement is a legal agreement between a landowner and a conservation organization that protects land while leaving it in private ownership. The restrictions of the easement, tailored to suit the particular property and landowner's goals, permanently limit a property's uses in order to protect its conservation values. The easement binds all present and future owners of the eased land. Conveying a conservation easement is a way of making a tangible commitment to the preservation of the natural resources, cultural heritage, scenic beauty, and open spaces of a property and the community in which it lies, for present and future generations.

Potential sources of funds for the purchase of a conservation easement on the Crum Woods include the Pennsylvania Department of Conservation and Natural Resources (DCNR) and the North American Wetlands Conservation Council (NAWCC), a federal program under the U.S. Fish and Wildlife Service. DCNR requires a 50% match to its grants as well as public access, a resource management plan, and no agricultural uses. NAWCC's focus is on migratory waterfowl (wetland, buffers) and requires a two-to-one match. Alumni donors and foundations whose missions include open space preservation or nature conservation would be potential sources of matching funds under either program.

There are costs associated with the sale of a conservation easement. Cost items are listed below with estimated ranges of potential dollar amounts for the Crum Woods.

- Baseline documentation/grant administration $8,000–10,000
  A requirement of the easement, this report lists the existing conditions of the land and the public policies served by its protection; part of the baseline documentation will be a repackaging of the contents of the current report.
- Property line survey* $40,000–50,000
- Appraisals (2)* $8,000–10,000
  Two appraisals are required by the state .
- Legal fees $5,000–10,000
  For preparation and revisions to the easement document and related documents.
- Title insurance/closing costs* $6,000–8,000
  State and county grant programs require title insurance on property interests they fund.
- Monitoring endowment $30,000–40,000
  Federal regulations on easement holders require that they have sufficient resources to monitor and defend their easements in perpetuity.

* Reimbursable costs under state and federal (NAWCC) programs

Recent examples of non-profit institutions that have sold conservation easements:

Musser Scout Reservation

Owner: Cradle of Liberty Council, Boy Scouts of America

Location: Marlborough Township, Montgomery County

Date: 2002

Acres: 860 (first phase of project to preserve the entire 1,196-acre Reservation)

Amount: $1,548,000

Funding Sources:

Pennsylvania Department of Conservation and Natural Resources Keystone Land Trust Assistance Program (50%)

Montgomery County Open Space Program - Private Organization Challenge Grant Program (50%)

The William Penn Foundation (providing reimbursement of some of the direct costs associated with the purchase)

Camp Horseshoe

Owner: Chester County Council, Boy Scouts of America

Location: West Nottingham Township, Chester County

Date: 1998

Acres: 193.5

Amount: $257,325

Funding Sources:

Pennsylvania Department of Conservation and Natural Resources Keystone Land Trust Assistance Program (50%)

Chester County Preservation Partnership Program (50%)

Appendix I. White-tailed Deer Management

The perpetuation of any healthy forest community depends on the ongoing establishment of tree and shrub seedlings and saplings in sufficient numbers to occupy the gaps that are created by periodic natural or human disturbance of the various structural layers (canopy, subcanopy, shrub). Even though other factors, such as acid rain, may be contributing to the problem, the lack of tree, shrub, and herbaceous regeneration in forests in the region results principally from an overabundance of white-tailed deer.

Researchers believe that our native forests evolved with deer densities of 5 to 10 per square mile (640 acres). At the beginning of the last century, white-tailed deer were nearly extirpated from Pennsylvania and other eastern states through over-harvesting and deforestation. By instituting game laws, state agencies had success in rebuilding the deer population. However, because hunting rules focused on providing a "maximum sustained yield" of game for hunters and not on maintaining healthy ecosystems, the forests of Pennsylvania suffered as the population soared. Statewide, the deer population now averages almost 40 per forested square mile. Twenty per square mile is considered the appropriate maximum level to allow any significant tree and shrub regeneration; a level of 5 to 10 per square mile is needed to sustain a high diversity of native species, including herbaceous plants.

Deer overabundance dramatically curtails the survival of native flora. Deer are browsers, which means their diet consists mainly of newly grown twigs of woody plants, mainly trees and shrubs. When deer populations are high, they consume all of the seedlings and saplings (collectively known as "regeneration"), as well as many tree seeds, particularly acorns, and herbaceous plants. It is believed that over 100 species of native wildflowers have been extirpated (become regionally extinct) in Pennsylvania partly as a result of overbrowsing by high deer populations. The resulting lack of cover, food, and structural diversity within forests has undoubtedly reduced populations of small mammal and bird species. Deer overabundance has degraded forests throughout the region.

Management Options

Methods to control the impacts of deer overabundance can be grouped into two categories, those that reduce the on-site population within a tract of land and those that restrict deer access to desired vegetation. The most frequently used and most effective reduction method is hunting. Populations can also be reduced through contraception and trap and transfer. Contraception, although very expensive and labor-intensive, has proven effective in arresting population growth under the right circumstances, whether through surgery or remote delivery from darts and bait. Appropriate situations, however, are limited to small, contained populations such as on islands or in fenced

parks and zoos. Trapping or darting deer and moving them to another location is the most expensive, difficult and ineffective deer control method. It is an option fraught with problems, the biggest of which is finding a location willing to accept more deer. Attracting well-fed deer into baited traps is the next challenge. Also, survival rates of transported deer have been low.

Methods of restricting deer access to vulnerable plants that are viable and cost-effective in certain situations include fencing, tree shelters, and deer repellents, although they all have drawbacks. Fencing is effective for small areas. Bowman's Hill Wildflower Preserve in Bucks County, Pennsylvania, has constructed an exclosure around its 100-acre property, which effectively protects its wildflower collection. Tyler Arboretum, 5 miles northwest of the College near Media, in 2000 installed a 12-foot-tall, 2-mile-long deer fence around 105 acres of its collection at a cost of $350,000 (including more than $50,000 to provide the means for vehicular access). In addition to its high initial cost, fencing requires constant monitoring and restricts not only deer movement, but also the movement of several other animal species. Tree shelters are effective in protecting a small number of individual trees from deer browsing, but they require high maintenance and are not useful for protecting shrubs or herbaceous plants. Repellents can also be effective in very small areas — a backyard garden, for example — where one needs only to reduce the browse damage to tolerable limits. Even in such limited situations, however, a user must be committed to continually monitoring application needs and experimenting with new products as deer adapt quickly to repellents, particularly in high populations.

Although one or a combination of these options can be used to control the impact of an overabundant deer population in a small area, typically a managed hunting program is the only economically feasible way of successfully protecting the forest and its wildlife habitat values in an area as large as the Crum Woods. To be effective, a deer management program must focus on removing does (adult females) from the population. Participating hunters should be required to take a doe (not just an antlerless deer) as a prerequisite for earning the privilege of taking a buck. This requirement should continue until the population falls to 5 to 10 deer per square mile. The target density must be maintained (or lowered further if necessary) for forest regeneration to be reestablished and sustained, for juvenile trees to grow beyond browsing height (6 feet), and for native wildflower populations to recover.

If approved by the College, a controlled archery hunting program (see below) could be instituted safely in several locations in the Crum Woods. Appropriate areas (large enough with relatively low use) include the Martin Forest and most of the Woods west of Crum Creek. The most efficient way to implement a program might be to engage a local hunting club. They could handle all program administration, including proficiency tests, the scheduling of hunting times, and data collection. The group should provide proof of insurance and be in close contact with the Woods manager to avoid conflicts with other activities in hunting areas.

In conjunction with a managed hunting program, fencing can be used to help in reestablishing regeneration in selected critical areas. The construction of temporary exclosures will not only accelerate successful regeneration, but also serve an educational function by graphically demonstrating the true impact of deer overabundance on forest vegetation.

Estimating Deer Impact

Monitoring vegetation indicators is a practical way to assess the effect of deer on an ecosystem. Vegetation can be assessed by two methods: (1) comparing the overall influence of deer browsing on existing vegetation to an established index or (2) quantitative sampling. The U.S. Forest Service and Penn State University have developed a five-level deer impact index to visually assess the level of deer influence on forest health:

> Deer Impact Index 1 – Very low: Occurs only within a well-maintained deer exclosure.
>
> Deer Impact Index 2 – Low: Species composition and height of regeneration is determined mainly by available light, nutrients and seed source. There is a well-developed shrub layer and native wildflowers are abundant and grow to their full size.
>
> Deer Impact Index 3 – Moderate: Evidence of browsing is common with a greater reduction in height and abundance of the most-preferred species than of the least-preferred species.
>
> Deer Impact Index 4 – High: Preferred species are sparse or absent and all plants are nearly the same height as a result of browsing. Vegetation in the shrub layer is sparse except for the least-preferred species (e.g., spicebush, American beech).
>
> Deer Impact Index 5 – Very high: A pronounced browse line is evident with virtually no vegetation below the browse line except for two rhizomatous fern species, hay-scented fern and New York fern.

The deer impact index is a qualitative measure; its utility for detecting change over intervals as short as one or two years is weak and its usefulness depends heavily on the level of experience and knowledge of the evaluator on food-plant preferences of deer, expected maximum sizes of various plant species under a variety of habitat conditions, and how to distinguish signs of deer browsing from plant damage by other animals and causes other than herbivory. Quantitative sampling is more time-consuming but its interpretation involves less judgment and specialized expertise. A quantitative approach could include periodic surveys along a transect or cataloging vegetation change within fixed plots. The latter could be used in conjunction with the construction of deer exclosures in the Crum Woods. Methods need to be scientifically rigorous if the

results are to be sufficiently credible to serve as the basis for labor-intensive and potentially costly deer management procedures. For example, the protocol should include:

- stratified random selection of areas to be sampled
- large enough sampling plots or transects or wide enough dispersion of smaller subsampling plots within each exclosure or control area to cover the range of spatial heterogeneity
- true replication with interspersion of treatment (exclosure) and control areas across the landscape
- sufficient replication for reasonably high statistical power, to increase the likelihood of early detection of relatively subtle differences

The data gathered within sampling plots or along transects may include:

- percent cover of each plant species below 6 feet (1.8 m) above ground surface (maximum height of deer browse)
- number of seedlings and saplings of each tree species
- special measures of indicator species (forest-floor species known to be vulnerable to deer but somewhat tolerant of moderate levels of browsing, e.g., Canada mayflower, Indian cucumber-root, and several trillium species); measures may include height of tallest plant or length of longest leaf in the plot, and number of flowering/fruiting individuals versus number of non-flowering/fruiting individuals of each indicator species in the plot

Standard methods for sampling design, data collection and analysis are detailed in several of the references listed at the end of Section 6: Monitoring Program.

Estimating Deer Abundance

The primary concern about deer overabundance is the associated impact on ecosystems and biodiversity, however, it is still important to monitor deer abundance to make certain that management actions intended to reduce or maintain deer populations actually do so. It is nearly impossible to make a full count of any animal species in the wild, but several methods have been developed to estimate the abundance of white-tailed deer.

Survey methods can be classified into two general types: indirect methods based on monitoring deer signs (e.g., tracks or fecal pellets) and direct methods that require

capturing or observing deer. Direct methods may deliver more accurate and precise population estimates but they tend to be prohibitively expensive.

Direct methods include the aerial survey, which has the advantage of covering large areas quickly and easily, although hiring pilots and renting aircraft are expensive. The main problem with using aerial surveys for white-tailed deer in this region is visual obstruction by vegetation. In a predominantly deciduous forest such as the Crum Woods, aerial surveys are performed only in winter but evergreen trees and shrubs, topographic features, and the dense cover of trees' and shrubs' trunks, limbs and twigs still obscure a large percentage of deer from aerial view. Researchers have shown that thermal imagery — flying at night using infrared-sensitive instruments — is far more effective than daytime aerial survey methods using visible light.

Another direct approach is the mark-recapture method, which involves marking individual deer and comparing the proportion of marked deer recaptured or killed in a subsequent roundup or hunt. This method is expensive because a large number of deer need to be marked — at least 45% of the deer if the population is small (less than 200). In addition, the method is based on the assumptions that marks are never lost and deer do not emigrate from the study area. The mark-recapture method has been shown to overestimate deer populations because of unknown mortality of marked deer and emigration from study areas. Accurate monitoring of mortality and emigration requires the use of radio-collars in place of marks. Another problem with this method is that every deer is assumed to have the same probability of being recaptured or taken by hunters, which is likely to be violated owing to differences between older and younger deer in wariness, ability to evade pursuers, and hunter preference.

Most indirect methods do not provide estimates of absolute abundance, but are intended to provide an index of relative abundance that can be used to detect changes over time within a particular area. For example, counts of the abundance of deer trails, tracks, deer sightings per kilometer walked on foot, intensity of browsing, abundance of fecal pellet groups, and number of deer killed on roads have all been used as indices of abundance. All of the index methods assume that potential sources of variability in the index (e.g., deer defecation rates, hunter effort, or movement by deer across the landscape) are constant over time so that the changes in the index over time reflect changes in population size alone.

Counting fecal pellet groups is the most widely applied means of indirectly estimating deer density. A typical method would be to visit a large sample of uniform-sized plots across the study area and eradicate all existing pellet groups on each plot, then return to those plots several weeks or months later and count the newly deposited pellet groups. Deer density can be estimated by assuming a daily defecation rate per individual deer. The assumptions of this method are that a random sample of plots has been selected, the defecation rate is known and remains constant among deer and surveys, and pellet groups are counted accurately on the plots. (In practice, the pellet group technique has often been applied somewhat differently. Surveys are usually performed in winter and the number of days is taken to be the time since leaf drop. This removes the labor

requirement of first eliminating all existing pellet groups on plots, but results are distorted by the precarious assumptions that all pellet groups deposited prior to leaf fall have been covered by leaves and that leaf drop occurred on a specific day.)

Although widely used, pellet group counts are subject to many sources of error, which may be minimized by careful design and execution of the specific protocol. They include observer skill and fatigue in detecting pellet groups, choice of plot shape, habitat (vegetation) influences on detection of pellet groups, and decay rate of pellets. The most sophisticated surveys apply the technique of "distance sampling" to account for differential detection among habitats, factor in the decay rates of pellet groups, and use a statistically based sampling design. However, even the most careful surveys are based on a number of questionable assumptions, including a constant defecation rate and no variation in decay rates among habitat types. Research on defecation rates indicates that they vary among seasons (presumably because of dietary changes) and among age and sex classes and that pellet decomposition rates differ according to habitat type. Despite their limitations, however, pellet group counts may be the most practical means of monitoring changes over time in deer densities in various parts of the Crum Woods.

Natural Lands Trust's Deer Management Program

At Natural Lands Trust, our goal is to preserve and enhance the plant communities within our preserve system to maximize wildlife benefits. With that goal in mind and based on an understanding of the requirements of the state wildlife code, we have instituted a deer management program that focuses on reducing deer populations to a level that will allow forest regeneration and survival of native herbaceous species. First, we employ tree shelters and fencing to protect vegetation from deer browsing and rubbing, and second, we implement controlled hunts to reduce the numbers of deer.

The rules that hunters must adhere to reflect an overriding concern for safety, not only for the participants of the management program but for other preserve users such as walkers and bird-watchers (see below). The mandatory proficiency test assures that hunters are familiar and competent with their sporting arm. A flagged map locates hunter positions for the preserve manager and other hunters. Participants wear bright N.L.T. armbands that allow preserve managers as well as others to tell from a distance if a hunter has permission to hunt. The rules place due emphasis on removing does from the population. Preferentially harvesting does brings populations to tolerable levels far more quickly than would a random removal strategy.

Operating the program requires relatively little staff time to administer. In fact, staff time expended in administration is readily made up through time saved by the reduction in staff patrolling time during the hunting season. Permitted hunters monitor unwarranted access to the preserve during the hunting season, enabling managers to attend to other responsibilities.

Natural Lands Trust 2003 Regulated Hunting Program
Rules and Regulations

Natural Lands Trust conducts controlled deer hunts on properties to manage deer populations consistent with the preserve's natural resource management goals. Hunters receiving permits for the deer management program are expected to conduct themselves in a safe, honest and ethical manner. Any hunter who does not act accordingly will have his or her hunting permit revoked immediately. Listed below are the requirements that must be met to receive a permit, examples of what the Trust considers unacceptable behavior, and the regulations that must be followed while hunting on any Trust preserve.

Permit Requirements

1. All hunters must attend a preseason orientation course to be conducted by the preserve manager.
2. All hunters must present proof that they have completed the Pennsylvania Game Commission Hunter/Trapper Education Course. Bowhunters must present proof that they have completed a Bowhunter Education Course.
3. Hunters must have an antlerless deer license for the deer management unit of the preserve
4. All hunters must pass a proficiency test using the sporting arm they plan to hunt with. For **firearms**, a hunter must place 4 out of 5 slugs in a 9-inch paper plate at 45 yards. No buckshot allowed. Shooting from a treestand 10 feet above the ground, an **archer** must place 5 out of 6 arrows in the vitals of a 3-D target. The target will be placed at 5, 10, and 15 yards from the base of the tree.

Unacceptable Behavior (includes, but is not limited to the following)

1. Shooting in marginal situations such as at running deer, when vital organs are obstructed, and at excessive distances.
2. Disrespect of Trust employees, adjacent landowners, and other preserve users.
3. Consumption of alcoholic beverages or use of controlled substances.
4. Failing to appropriately follow up every shot.
5. Displaying game animals unnecessarily.

Hunting Regulations

1. The Trust will determine the days and hours of hunting permitted at a site.
2. Hunters must comply with all Pennsylvania Game Commission regulations (including returning report cards).

3. Hunters must endeavor to harvest an antlerless deer. Any hunter that does not make a good faith effort to harvest ann antlerless deer will have their permit revoked. Archers must take an antlerless deer before being eligible to harvest a buck.
4. Hunters must hunt at least 20 hours.
5. Only two shells can be loaded at any one time (one shell in the chamber, one in the magazine).
6. Only portable tree stands may be used and hunters must wear a safety belt. No screw-in steps are allowed. All tree stands must be removed by January 26th, or they will be forfeited.
7. Crossbows and .410 shotguns are not allowed.
8. Hunters must follow the hunting procedure listed below.

Hunting Procedure

A metal box will be placed in a convenient spot, accessible to all hunters. The box will contain armbands, a map of the preserve, and the hunting log. ***Prior to each hunting stand the hunter must:*** (1) remove one of the armbands from the box and put it on the exterior of his or her hunting coat (once the supply of armbands is exhausted, no additional hunters may hunt until a hunter returns from the field and returns an armband to the metal box); (2) mark the map to indicate where they plan to hunt; (3) sign in on the hunting log; and (4) display a parking permit on the dashboard of their vehicle. ***While hunting, the hunter must:*** (1) wear the armband; and (2) carry their permit. ***At the end of each stand, the hunter must:*** (1) return the armband to the metal box; (2) remove the mark from the map; and (3) fill in the hunting log completely.

Termination Procedure

If the preserve manager witnesses a case of Unacceptable Behavior or a violation of one of the Hunting Regulations by a permitted hunter, or is informed of such an incidence by a reliable source, he will abide by the following procedure to address each incidence:

1. The preserve manager will verbally inform the hunter of the infraction.
2. The hunter will be provided the opportunity to respond to the accusation.
3. If, in the opinion of the preserve manager, the hunter has clearly exhibited an Unacceptable Behavior or has violated one of the Hunting Regulations, he will verbally inform the hunter that his hunting permit is revoked immediately.
4. If there are legitimate extenuating circumstances surrounding a violation of Hunting Regulation 6 or 8, the hunter will be given a warning. A second violation of these regulations will result in immediate loss of hunting privileges. Violations of any other Hunting Regulation or Unacceptable behavior rule will not receive a warning and will result in immediate termination of hunting privileges.
5. The hunter will be notified in writing of a warning or the loss of hunting privileges.

Appendix J. Invasive Vegetation Control

One of the most serious problems encountered in the management of open space in southeastern Pennsylvania is the presence of invasive vegetation. If left unchecked, invasives can rapidly compromise ecosystem integrity and the process of natural succession in natural areas. By displacing native vegetation they homogenize the structure and food resources of a site, thereby reducing its habitat value for native fauna, particularly songbirds.

Historically, land use in the region has been dominated by agriculture and logging, which, together with suburban development, have thoroughly disturbed native vegetation. The division and clearing of land parcels have replaced forest with "edge" as the prevailing condition, the state that is most highly favorable to the proliferation of invasives. The misguided promotion of some of the most invasive of introduced species for erosion and livestock control as well as horticultural plantings has given rise to virtually limitless seed sources and widespread dispersal of numerous invasive plants.

The control of invasive plants will be a perpetual concern of land managers in this region. The extensive edge areas and seed sources and the prolific nature of these plants guarantee that even with complete eradication on a given property, invasives will quickly reestablish themselves as a serious management problem. A strategy for coexisting with these plants is needed — one that will minimize their effects on the aesthetics and ecological stability of a property, with a minimum of management effort.

The presence of invasive plant species complicates the goal of maintaining a healthy forest as invasives compete vigorously with preferred native species for "growing space." Given their rapid growth rates, often prolific reproduction by seed or vegetative spread, and the absence of the specialist predators and pathogens that keep them in check in their native habitats, invasives are often able to outcompete native species. Most are particularly well adapted to colonize disturbed areas.

In order to perpetuate a healthy forest, including native animal populations, it is necessary to deal with invasives aggressively, in concert with an effort to reduce (or maintain) the deer population to (at) a density of 5 to 10 deer per square mile. If the invasive plant and deer overbrowsing problems are allowed to reach crisis level (probably within the next 10 to 15 years or after the next severely damaging windstorm), the task of restoration will become even more formidable.

Management Strategy

Often the most difficult step in controlling invasives is deciding what to do first. Creating a "plan of attack" is critical in order to make the most efficient and effective use of limited staff time. Although it may seem logical to address the most severely

invaded areas first, this may not be the best use of resources. The following two rules may help focus management efforts.

The first rule is that, in general, the future rate of forest degradation is inversely proportional to the current level of degradation. When a tree within a healthy, closed-canopy forest is toppled by invasive vines or a gap is colonized by an invasive tree, the resulting loss of growing space has a major impact on the entire forest stand, by providing a seed source for the rapid spread of invasives from that point. On the other hand, the loss of a single tree in a heavily degraded, open-canopy area creates relatively little change in the total amount of growing space in the stand that is controlled by invasives.

The second rule is that management efforts should be focused on restoring that part of the plant community that controls the most growing space. In a forest community the canopy trees take up the majority of the growing space. Once the canopy is free of invasive impact, the manager can proceed to the next layer until the ground level is reached.

The focus of initial restoration efforts, therefore, should be to halt the degradation of the canopy layer in the healthiest areas, moving then to the moderately invaded areas, and so on to the most degraded areas. Those areas that are severely invaded should, for now, be left for "dead." Since they essentially cannot degrade any further, their restoration (which will usually require significant resources, including heavy equipment and years of high maintenance) is best left until the healthier, less impacted sites are stabilized. This approach is also healthier, psychologically, for the personnel involved in restoration. Spending the initial phase of a project stabilizing the majority of a site is more rewarding than struggling through a highly degraded area that is only a small portion of the site.

Priorities may need to be modified, for greatest short-term efficiency in the allocation of labor and best long-term results, according to the time of year or availability of labor. For example, the cutting and herbiciding of understory invasive trees is best done during fall and early winter when sap is flowing into the roots, whereas the planting of seedlings is best done in the late winter and early spring. If labor is first available in the spring, then it would be best to plant seedlings in moderately to heavily invaded forest areas first and wait till the fall to cut the invasive trees in lightly to moderately invaded areas.

It cannot be overemphasized that any invasive plant control program must be undertaken in concert with a serious effort to reduce the overabundance of deer (see Section 3.2.3 and Appendix I). Without sufficient native regeneration, any effort to restore native species to degraded areas will be futile.

Management Options

In natural area management, the most efficient and effective strategy usually results from basing management goals on a thorough understanding of the environmental forces in the area and adopting only those that work with, and not against, these forces. This is true in developing a strategy for minimizing the impact of invasive plants. Any attempt to alter the vegetation of a site will succeed or fail according to its effects on the major forces (light, water, inorganic nutrients, temperature, humidity, soil structure and other factors collectively known as the "growing space") that support plant growth in that area. Given that growing space in any area is finite, successful management will result from those practices that make more growing space available to desirable species (native members of natural communities) and less to non-desirable species (introduced invasives).

There are many management options for controlling invasive vegetation. These include physical removal, cutting, planting, herbicides and fire. Usually, the control of invasives on any given site requires a combination of two or more methods. The most effective mixture and timing will be unique to each site. What is common to all sites is the fact that the prolific nature of invasive plants mandates periodic monitoring and control to prevent a major disruption to the aesthetics, native biodiversity and ecosystem function of the impacted site.

Physical Removal

The most effective practice is the selective removal of invasives without disturbing the surrounding native vegetation. The invasive plant is denied growing space and the surrounding desirable vegetation is well-positioned to occupy the vacated growing space. This approach is preferable wherever possible, although it may be limited in particular cases as a practical alternative by the availability of workers and equipment relative to the size, quantity, and type of invasive(s) present.

Relatively small quantities of invasives can be effectively removed through manual pulling, digging with hand tools (shovel or spade) or pulling with a heavy-duty truck or tractor. One specialized hand tool that works well on small single-stemmed plants is called by one manufacturer a *Weed Wrench*. It is designed to clamp to the base of a tree or shrub and lever the entire plant out of the ground. A tractor-mounted front-end loader is ideal for removing larger trees or shrubs by several methods. One method entails elevating the lower branches with the bucket while a chain (a logging slip chain is best) is attached to the base of the plant and then, by raising the bucket, the plant can be removed from the ground. A second, easier tractor method is to use a single fork attachment on the front-end loader to pop the shrub out by positioning the fork under the crown (the swollen area from which the roots and stem emerge) and raising the bucket. The third, and most efficient, method requires replacing the loader bucket with a new tool called a *Brush Brute* — a 4 to 6-foot steel frame with 18-inch "teeth." With this tool the operator simply drives into the unwanted shrub or small tree until the base

of the plant is impaled between the teeth and then lifts the entire plant out of the ground.

Regardless of which means is employed, it is generally desirable to remove as much of the root system as possible to prevent resprouting, although removal of the crown is usually sufficient to prevent rapid reestablishment of the plant. In individual cases the success of this method depends on the thoroughness with which the plant is removed and the speed at which desirable vegetation can occupy newly available growing space.

Cutting

Removing some or all of the photosynthetic (food-producing) area of invasive plants without disturbing the surrounding vegetation is another way to redistribute the available growing space and control invasives. It is less effective, but also less labor intensive, than physical removal. Cutting the plant with a pruner, handsaw, or lightweight chainsaw reduces its aboveground growing space without disturbing surrounding vegetation. However, the entire root system and any uncut stems can resprout and reoccupy the growing space. For this reason, it is best to cut the plant as low as possible to the ground and to add an herbicide application (refer to the Herbicides section, below, for further details).

This option is most appropriate for controlling invasives in forested areas. In this situation, leaves of the surrounding vegetation (trees) are often situated above the target plant material. Because the surrounding trees limit the sunlight needed for food production, a cut plant is forced to rely on stored root reserves to maintain the remaining parts of the plant and support new leaf growth. Although invasives are usually able to survive cutting, they may be weakened sufficiently to slow their full recovery for an extended period.

Cutting is less effective in open areas. Typically, resprouting ability and rapid growth allow invasives to quickly reoccupy the available growing space. The problem is alleviated only temporarily; cutting will be required again within a few years. This is particularly true at edge sites (where open fields or lawns meet forests) and hedgerows. There the vines gain the added benefit of tree support, which they can utilize to occupy greater growing space to the detriment of the trees.

Late fall and winter are the most efficient and least arduous times to perform cutting operations. Problem areas are more easily traversed and cool-weather clothing gives added protection to the work crew. Following initial treatment, an annual or biennial inspection and control schedule should be adopted to prevent initial conditions from recurring. After a thorough first treatment, frequent but small-scale treatments are effective in preserving the native diversity, ecosystem integrity and aesthetic quality of a site.

Planting

Another option to take away growing space from invasives is by planting native trees and shrubs to increase their density and shade out invasives. It is particularly important to minimize the amount of interior and exterior edge of a forest (high light areas where invasives thrive) by encouraging native species growth in forest gaps and rounding off sinuous or concave borders with open areas.

In areas where invasives are a significant component of the vegetation, it is desirable to plant trees and shrubs where invasives have been removed. Killing or removing the invasives often disturbs the soil surface, giving a strong advantage to opportunistic species as plants colonize the newly vacated growing space. Invasives will quickly reoccupy such a site unless they are suppressed by other plantings.

Planting should occur in early spring or fall to optimize plant survival. Because they must compete with invasives, only species highly adapted to a site's conditions (particularly light and soil water availability) should be planted.

Herbicides

In most cases the use of herbicides alone is not an effective long-term solution for controlling invasives. Difficulties in delivering adequate amounts to the target plants at the correct time in their growth cycle the near-impossibility of avoiding collateral damage to native plants and other organisms, and the potential health risks to workers are all drawbacks to their use. In addition, inherent in the sole reliance on herbicides is a "once and done" attitude that is not conducive to the long-term control of invasives. Used appropriately, however, herbicides can be an important tool for land managers in certain situations. Herbicides should be applied only by personnel properly trained in both the safe use of each herbicide and the identification of desirable versus undesirable species.

To safely administer herbicides to the target plant it is best to minimize the aboveground volume of the plant prior to herbicide application. To control small trees, shrubs, or vines, an herbicide with glyphosphate (such as *Roundup* or *Rodeo*) should be applied to the fresh sprouts two weeks after cutting. Larger plants can be most effectively controlled by applying an appropriate formulation of the herbicide triclopir (such as *Garlon, Escort* or *Clean Cut*) or glyphosphate directly to the freshly cut stump. This second method works best in fall and winter when sap flow is into the roots.

Fire

Fire has played an important part in shaping local plant and animal communities for thousands of years. Fire was a frequent occurrence within forests, following major disturbances such as windfalls or insect defoliation, and on the open grasslands, shrublands and barrens scattered throughout the region. In addition, Native Americans living in the region used fire for centuries or thousands of years for numerous reasons,

for example, to drive game and to rejuvenate food resources such as berry patches and pasture for game species. Fire suppression over the last century has modified the plant composition of forest communities. Many eastern forests are now in transition from an oak- and hickory-dominated canopy to a fire-sensitive red maple-dominated canopy.

The use of fire to control invasives by giving an advantage to desirable native species is an exciting new application for an old management tool. The difficulty in utilizing this tool is the obvious destructive power that can arise from its misuse or improper application. Local governments and fire companies are often not receptive to the use of fire to restore and maintain native biodiversity and ecosystem function. Some fire companies, however, use controlled burns as training exercises, for example, to maintain the Pink Hill serpentine barren in nearby Tyler Arboretum. In certain circumstances, the potential benefits for the control of invasives may be sufficient to warrant rising to the bureaucratic challenge.

As with herbicides, only properly trained individuals should utilize fire as a management tool. To be effective and safe, weather and fuel conditions must meet narrow parameters (the "burn prescription"). In this region it is usually best to burn in early spring, a time when many natural fuels reach a peak of flammability but weather conditions typically make containment simpler. Furthermore, invasives usually sprout earlier than native species, making them vulnerable to fire at a time when many natives are highly fire-tolerant. Before undertaking a burn it is also crucial to acquire any necessary permits, notify neighbors, and coordinate with local authorities and, of course, the local fire company.

Recommended Techniques and Procedures

Groundcover and Vine Removal

Equipment: Pruners, pruning saws, loppers, blade weedwhips, chainsaws, herbicides

Groundcovers can be pulled on a regular basis or herbicides can be used to control or eliminate patches. A mixture of *Garlon* and diesel fuel has been used successfully when sprayed on foliage in the winter. Care must be given to not spray non-target species.

Start by cutting larger vines on canopy trees and work down to saplings and shrubs. Cut woody vines at ground level and at least 5 feet above ground level and remove from trees if removal won't cause damage. Immediately following cutting, large stumps should be painted with a systemic herbicide such as *Roundup* or *Garlon*.

It should be noted that while invasive vines pose a significant threat to the forest, there are native vine species within Crum Woods that have high food value for wildlife. Poison-ivy, Virginia creeper and grape should not be cut from trees unless they begin to seriously compromise the health of the tree. Usually, this only happens with grape,

which can eventually overtop the canopy of a tree. At this point the grape should be cut and not treated with herbicide so that it can resprout.

Shrub and Sapling Removal

Equipment: Pruners, pruning saws, loppers, blade weedwhips, *Weed Wrench*, chainsaws, tractor-mounted brush hog, front-end loader, herbicides

Eliminate or control invasive and undesired shrubs and saplings by manually or mechanically pulling or by cutting. Stumps cut manually should be immediately painted with a systemic herbicide such as *Roundup* or *Garlon*. In areas that have been brush-hogged, cleanly recut all saplings over 2 inches in diameter and immediately paint with the systemic herbicide. Limbs and related debris can be flychipped on-site or removed if there are fruits with viable seeds.

Tree Removal

Equipment: Pruners, pruning saws, loppers, *Weed Wrench*, chainsaws, front-end loader, herbicides

In areas adjacent to trails and other high-use locations, drop invasive and hazardous trees without damage to surrounding desirable trees and either let lie or section trunks to create brush piles for wildlife habitat (see below). Trunks and limbs of Norway maple that are large (> 6-inch diameter) and straight (> 8-foot sections) may be useful for trail stabilization and restoration. Some other invasive tree species such as ailanthus will decay rapidly and are not useful for this purpose. Stumps of felled trees should be cut flush to the ground and immediately treated with a systemic herbicide such as *Roundup* or *Garlon*. In many areas ailanthus will root-sprout vigorously following cutting, even with herbicide treatment. If this occurs do not cut, but apply herbicide directly to the bark at the base of the tree using oil-based *Garlon* mixed with a basal oil. For more information refer to the Nature Conservancy's weed-control website (http://tncweeds.ucdavis.edu/esadocs/documnts/ailaalt.html). Smaller limbs and related debris should be left to rot or fly-chipped on-site. In appropriate areas, larger (> 6-inch diameter) trees can be girdled to create snags for cavity-nesting wildlife. All dead trees, snags, or branches that do not pose a safety hazard or a threat to the ecological health or stability of the forest should be left in place for their wildlife habitat benefits.

To create a brush pile, first build a base by placing four large logs, set 1 foot apart and parallel to each other, and then place four more logs of the same size, stacked perpendicular to the first logs. Add brush to the top and sides, starting with the larger limbs first, then adding smaller pieces until the pile is about 6 feet high and 6 feet wide.

Planting

As mentioned previously, it is particularly important to establish trees and shrubs in forested areas where invasives have been removed. This can be done through natural or artificial (planting) regeneration. The former is the preferred method because new seedlings will be derived from a gene pool that has evolved under the environmental conditions of the property over centuries or thousands of years.

Only wild-type (no cultivars) native tree and shrub species appropriate to site conditions should be used. Selecting species that are high in wildlife food and cover value increases the benefits. They should also be locally grown if possible. Ideally, they would be grown from seeds or cuttings collected on-site. Trees should be 4 to 6 feet tall at planting to help assure that they can outcompete invasives and so that most of their foliage is above the reach of browsing deer. Container trees, both potted and in tree bands, are easier to plant and have a much greater survival rate than bare-root trees, especially if soil conditions in the planting area become dry. Using container trees also extends the planting season.

Forest gaps should be planted with trees on roughly 10-foot x 10-foot spacings and protected from deer damage with fencing, tree shelters, flexible tree wraps, or rigid stakes. Fencing and tree shelters prevent deer from browsing leaves and buds. The tree wraps and stakes minimize damage to the bark and cambium layer (girdling) of young trees caused by antler rubbing. The wraps should cover the trunk from 1 foot to 5 feet above the ground. The stakes should be placed in the ground close to, and on opposite sides of, the trunks. They can be made of wood, metal, or other rigid materials (including bamboo) and should be at least 5 feet tall (above ground level). Shrubs should be a minimum of 18 to 24 inches tall at planting. Where it is not practical to reduce and maintain deer at a density of 5 to 10 per square mile, only the most highly unpalatable species, such as spicebush, should be planted.

Planting design should be spaced to allow access to control competing vegetation, but close enough for the canopy to close quickly. It should also be naturalistic in form (i.e., straight lines or rows should be avoided).

Watering at the time of planting is recommended, especially if the plant is not dormant or planted during warm or dry weather. If water is easily accessible, water all plants at the time of planting to help remove air pockets from backfilled soil. Monitor the plantings for at least the first summer, watering them if conditions become dry. A little maintenance goes a long way. If available, put a layer of mulch 2 to 3 inches thick over the planting area, but no closer than 2 inches to planted trees' and shrubs' trunks.

Schedule

Invasive and undesired vegetation is best removed in September through February when systemic herbicides are most effective (when sap is flowing into the roots).

Conduct removal preferably when the ground is frozen, otherwise when the ground is dry.

Plant trees and shrubs in early spring before they leaf out or in early fall to allow for root growth before the ground freezes. If needed, install flexible tree guards in August and remove in January, until the tree is large enough (2 inches in diameter) to withstand buck rubs.

Ongoing Management

Following restoration, every effort should be made to minimize future disturbance to forest areas, from both natural and human sources. This includes removing any trash and monitoring annually for intrusion or regrowth by invasive or other undesirable plants.

Control invasive trees and shrubs by spot spraying or wick application of an appropriate systemic herbicide or by manual or mechanical pulling. Areas that are disturbed by removal should be replanted with native trees and shrubs and mulched with woodchips or on-site leaf litter. Any resprouting invasive and undesirable vines should be prevented from climbing into trees and shrubs, at a minimum by pruning. They should eventually be eliminated by spot spraying or wick application of an appropriate systemic herbicide or by manual or mechanical pulling and replanting of the area with native trees and shrubs.

Until natural regeneration becomes adequate, the planting of trees and shrubs should continue on an as-needed basis to assure that sufficient regeneration is available to replace canopy trees as they die. Reduce vegetative competition through selective cutting or herbicide use around the bases of trees during the growing season until the canopy has closed.

Table J1. Severely invasive introduced species of plants, animals and microorganisms currently associated with the greatest harm to native biodiversity in the Crum Woods, or considered as posing a grave threat. All are native to Eurasia.

		description	references on biology and control methods
Norway maple	*Acer platanoides*	tree	Nowak and Rowntree (1990); Webb and Kaunzinger (1993); Kloeppel and Abrams (1995); Wyckoff and Webb (1996); Webb et al. (2000)
hemlock woolly adelgid	*Adelges tsugae*	insect that causes severe harm to native conifers, especially eastern hemlock	McClure (undated); McManus et al. (2000); Morisawa (2000a); Stimmel (2000); Smith-Fiola (2001)
goutweed	*Aegopodium podagraria*	perennial herb	
garlic-mustard	*Alliaria petiolata*	biennial herb	Rowe and Swearingen (undated); Lhotska (1975); Patterson (1976); Cavers et al. (1979); Byers and Quinn (1988); Nuzzo (1991, 1993a, 1993b); Baskin and Baskin (1992); Nuzzo (2000)
oriental bittersweet	*Celastrus orbiculatus*	liana (woody vine)	Bergmann and Swearingen (undated); Dreyer (1994)
chestnut blight	*Cryphonectria parasitica*	fungus that has nearly eliminated American chestnut, once the most abundant tree in upland forests across most of the central Appalachians and Piedmont	Griffin (2000)
dogwood anthracnose	*Discula destructiva*	fungus that causes severe harm to the native flowering dogwood	
burning-bush	*Euonymus alatus*	shrub	Morisawa (2000b)

(continued on next page)

Table J1 (continued)

		description	references on biology and control methods
English ivy	*Hedera helix*	prostrate or climbing woody vine	Swearingen (undated-a); Morisawa (1999)
border privet	*Ligustrum obtusifolium*	shrub	Konno et al. (1998); Stromayer et al. (1998); Batcher (2000)
Japanese honeysuckle	*Lonicera japonica*	creeping shrub or liana	Friedland and Smith (1982); Hardt (1986); Nyboer (1992b); Dillenburg et al. (1993a, 1993b); Robertson et al. (1994); Schierenbeck et al. (1994); Nuzzo (1997)
Amur honeysuckle	*Lonicera maackii*	shrub	Batcher and Stiles (undated); Williams (undated); Hoppes (1988); Luken (1988, 1993); Luken and Mattimiro (1991); Nyboer (1992a); White and Stiles (1992); Williams et al. (1992); Robertson et al. (1994); Schierenbeck et al. (1994); Luken and Goessling (1995); Luken and Thieret (1996); Schmidt and Whelan (1999)
Dutch elm disease fungus	*Ophiostoma ulmi*	fungus that causes severe harm to native slippery elm and American elm	
phragmites, common reed	*Phragmites australis*	very large perennial herb; the species is native to both North America and Eurasia, but the invasive form is thought to be descended from Eurasian populations	Reimer (1973); Howard et al. (1978); Mook and van der Toorn (1982); Hara et al. (1993); Marks et al. (1993)
Japanese knotweed	*Polygonum cuspidatum*	very large Eurasian perennial herb	Remaley (undated); Patterson (1976); Beerling (1990, 1991); Seiger (1991)
lesser celandine	*Ranunculus ficaria*	perennial spring-ephemeral herb	Swearingen (undated-b)
multiflora rose	*Rosa multiflora*	upright or often climbing shrub	Patterson (1976); Amrine and Stasny (1993); Robertson et al. (1994)

Table J2. Other invasive introduced plant species, which cumulatively reduce biodiversity in the Crum Woods. Some of these species may become severely invasive in time.

		description	references on biology and control methods
tree-of-heaven	*Ailanthus altissima*	tree	Swearingen and Pannill (undated); Patterson (1976); Hoshovsky (1988)
five-leaved akebia	*Akedia quinata*	liana or creeping shrub	Reese et al. (undated); Waterson (1972); Levenson (1975)
Japanese angelica-tree	*Aralia elatus*	tree	
crownvetch	*Coronilla varia*	herbaceous plant aggressively spreading in open areas	
Indian strawberry	*Duchesnea indica*	herbaceous plant aggressively spreading in the forest	
gill-over-the-ground	*Glechoma hederacea*	herbaceous plant aggressively spreading in the forest	
Japanese hops	*Humulus japonicus*	herbaceous plant aggressively spreading in open areas	
purple loosestrife	*Lythrum salicaria*	herbaceous plant aggressively spreading in open areas	Thompson et al. (1987); Heidorn and Anderson (1991)
Japanese stilt grass	*Microstegium vimineum*	herbaceous plant aggressively spreading in the forest	Fairbrothers and Gray (1972); Barden (1987); Hunt and Zaremba (1992); Redman (1995)
Japanese plumegrass	*Miscanthus sinensis*	herbaceous plant aggressively spreading in open areas	
daffodil	*Narcissus pseudonarcissus*	herbaceous plant spreading in the forest	
Japanese spurge	*Pachysandra terminalis*	creeping shrub	
royal paulownia	*Paulownia tomentosa*	tree	Remaley (undated); Williams (1993a, 1993b)
Amur corktree	*Phellodendron amurense*	tree	Morisawa (2001)

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Table J2 (continued)

		description	references on biology and control methods
mock-orange	*Philadelphus* sp.	upright shrub	
mile-a-minute	*Polygonum perfoliatum*	herbaceous plant aggressively spreading in open areas	Moul (1948); Hickman and Hickman (1978); Hill et al. (1981); Reifner (1982); Mountain (1989); Mitchell (1995)
bird cherry	*Prunus avium*	tree	
garden bamboo	*Pseudosasa japonica*	upright shrub	
jetbead	*Rhodotypos scandens*	upright shrub	
black locust	*Robinia pseudoacacia*	tree	Converse (1984)
sapphire-berry	*Symplocos paniculata*	upright shrub	
linden viburnum	*Viburnum dilatatum*	upright shrub	
doublefile viburnum	*Viburnum plicatum*	upright shrub	
Siebold viburnum	*Viburnum sieboldii*	upright shrub	
periwinkle	*Vinca minor*	creeping shrub	
Japanese/Chinese wisteria	*Wisteria frutescens/sinensis*	liana	Thomas (1993)

Appendix K. Trail Design and Maintenance

Adapted from: *Trail Design, Construction, and Maintenance*, by William Birchard, Jr. and Robert D. Proudman, Appalachian Trail Conference, 1981; *Non-Motorized Trails, An Introduction to Planning and Development*, Pennsylvania Department of Environmental Resources, Bureau of State Parks, Division of Outdoor Recreation, The Pennsylvania Trails Program, 1980; and *AMC Field Guide to Trail Building and Maintenance (2nd Edition)*, by Robert D. Proudman and Reuben Rajala, Appalachian Mountain Club, 1981.

General Guidelines

In general, three types of guidelines should be followed in constructing new trails and maintaining existing trails: recreation enhancement, environmental protection, and public use and safety. If followed during trail layout, they will result in trail alignments that offer a more aesthetically pleasing and varied recreational experience, a more stable trail which can be maintained with less expense, and a safer and more enjoyable outdoor experience for users. In general, the more time spent during this phase of trail planning, the better the trail.

Recreation Enhancement

- Trails should be varied so as to enhance the user's enjoyment and visual experience.
- Trails should provide scenic views and incorporate points of interest such as historic structures or sites, wetlands, ponds or rock outcrops.
- Trails should be buffered from the sight, sound and hazards associated with manmade features, including roadways, buildings, and developed land uses.
- The trail designer should make creative use of vegetation to enhance the hiking experience.
- Trails should blend into the natural surroundings by maintaining continuity and regularity in the way they traverse the land.
- The trail designer should look for varying vegetative cover, avoiding alignments through continuous stands of similar vegetation.
- Trails should not have long straight sections which are unbroken by vegetation or topography. Short trail sections with many broad turns are desirable.
- Sudden changes in direction or too much meandering should be avoided.
- Planting showy native plants and butterfly/hummingbird-attracting plants in a naturalistic style in key areas along trails can greatly improve user enjoyment.
- Locating resting areas (benches, etc.) near features such as streams and ponds will allow users opportunities to enjoy the sights and sounds of the resources on the property.

Environmental Protection

- Every attempt should be made to position trails outside of environmentally sensitive areas, but with careful planning, a trail may incorporate a special features of the landscape into its design without adverse environmental impact.
- When locating a trail within its corridor, primary emphasis should be placed upon characteristics of soils and topography which control trail stability.
- Trails should fit the land by following the contour of the landscape.
- Trails should not go straight up steep grades.
- Areas having slopes in excess of 20% should be avoided, unless those areas are to be paved or otherwise stabilized.
- Soils which are deep, well drained, resistant to erosion, and do not have high seasonal water tables are most suitable for trail development.
- Where trails follow steep grades, sidehilling should be used to reduce grades and erosion, as well as to improve surface drainage.
- Switchbacks should be used when going up steep gradients where sidehilling cannot gain elevation fast enough.
- Switchbacks should not be visible from one another.
- Wide turns should be used in switchbacks to limit shortcutting, particularly where the trail is in an open hardwood forest where users can see ahead.
- Trail layout should provide for low impact on sensitive resources, such as wetlands. Main trails should bypass these resources where possible, with only secondary trails providing access to them. If highlighting these areas, special precautions should be taken to reduce the impact of hikers through the use of bridges and elevated walkways.
- Side trails leading to fragile resource areas should generally be longer and more difficult so as to discourage the majority of main trail users from using them.

Public Use and Safety

- Where there are road crossings, the hiker's exposure should be minimized by crossing in the shortest practical manner, usually at right angles, with adequate sight distances.
- Trails should not parallel road rights-of-way.
- Trails should avoid areas of streams and ponds with steep banks, deep water, or other potential hazards to children.
- Where trails are in the vicinity of developed land uses, they should have as wide a buffer as possible, and as long sight lines as possible, so as to keep potential conflicts with adjacent landowners to a minimum.

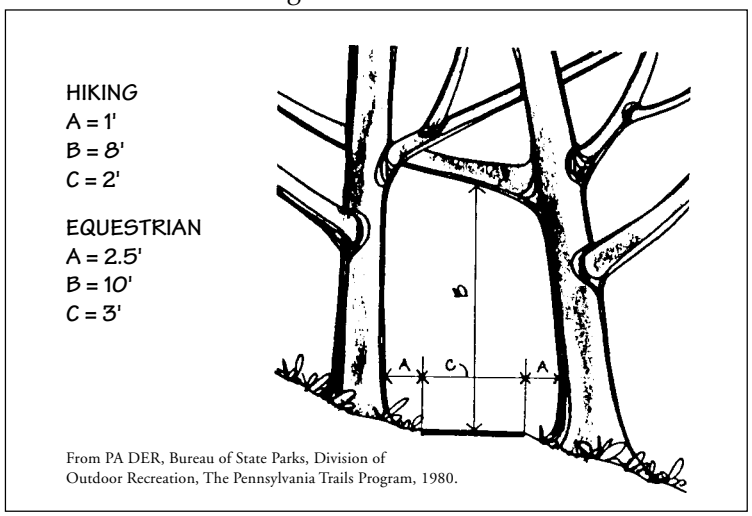
Trail Construction

Trail Clearing

If an old trail should be re-routed or a new trail is needed, the general alignment should be walked and flagged to determine exactly how the treadway should wind and dip, which rocks should be removed and which trees should be cut. This is a critical step in the trail building process, as slight shifts in the alignment can significantly affect drainage and treadway durability.

After the precise location of the trail is determined, the treadway should be cleared. For hiking trails, a 2 ft. treadway should be cleared with all projecting limbs cleared an additional 1 ft. for a total horizontal width of 4 ft. For equestrian trails, a 3 ft. treadway should be cleared with all projecting limbs cleared an additional 2.5 ft. for a total horizontal width of 8 ft. The trail should be cleared to a vertical height of 8 ft. for a hiking trail and 10 ft. for an equestrian trail *(Figure 1).*

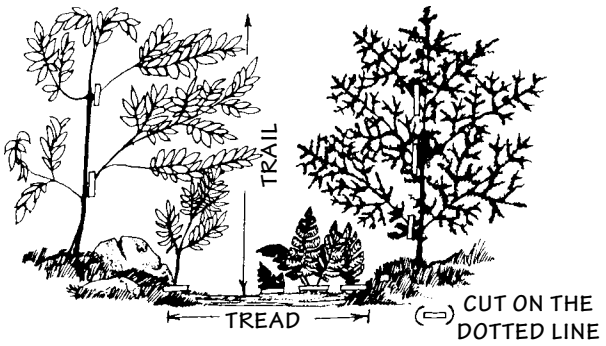
FIGURE 1: Trail Clearing Dimensions



From PA DER, Bureau of State Parks, Division of Outdoor Recreation, The Pennsylvania Trails Program, 1980.

In clearing trails all shrubs, vines, low-hanging branches, blowdowns, small trees, and fallen logs should be removed. Shrubs and small trees should be cut flush with the ground surface. Care should be taken not to disturb the ground surface or to pull plants out by the roots as this will lead to erosion of the treadway *(Figure 2).* Large trees fallen across the trail should be left in place by making two cuts and removing a 4 ft. wide section from the trunk across the trail *(Figure 3).* If motorbikes or mountain bikes are a problem, the logs can be notched to provide a flat surface for hikers, yet prohibit the passage of wheeled vehicles.

FIGURE 2: Trail Vegetation Removal



From Proudman, Robert D. and Reuben Rajala, 1981.

When clearing is completed, cuttings should in general be scattered in areas adjacent to the trail and left to decompose. It is necessary to collect the cuttings and remove them from the immediate trail area only where it is adjacent to public roads and developed areas.

In the first year of a trail, repeated clearing will be required to deter continued vegetation growth. In subsequent years, clearing will probably be necessary only two or three times a year. The exception would be in the areas of open fields and grassy areas where mowing may be required if trail use is not adequate to maintain a clearly visible treadway.

FIGURE 3 : Blowdowns

From Proudman, Robert D. and Reuben Rajala, 1981.

Treadway Stabilization

The type of tread surface on trails will ultimately be determined by its rate of use and the terrain through which the trails pass. Initially, once a trail has been cleared, it should be surveyed to ascertain where special measures should be taken to stabilize the treadway. These special measures will primarily include treadway hardening and erosion control measures. Most problems are likely to occur where a trail traverses steep slopes and wet areas, or where surface water drainage flows across the trail during storms.

In most areas there will be no need for actual trail construction, as careful trail design should have selected stabilized areas. In existing stable areas with slopes of less than 10%, the exact alignment of the treadway can be located by sweeping herbaceous and trailing plants and leaf litter off the path. If with time and use initially stable areas begin to show signs of wear and erosion, then some stabilizing type of material, such as wood chips or crushed stone, should be placed on the treadway.

If a new trail must be routed through wet areas, steps should be taken to harden the treadway before it deteriorates. There are four basic techniques typically used to accomplish this *(Figure 4):*

Drainage Ditches – The first step in trail hardening in wet areas is to try to enhance the drainage by creating small drainage ditches. These ditches should be dug at the lowest points along the trail, and be 1 ft. wide, 1 ft. deep, and anywhere from 3–20 feet in length. They should also be clear of roots and rocks, have sloping sides that prevent collapse, and be cleaned out annually.

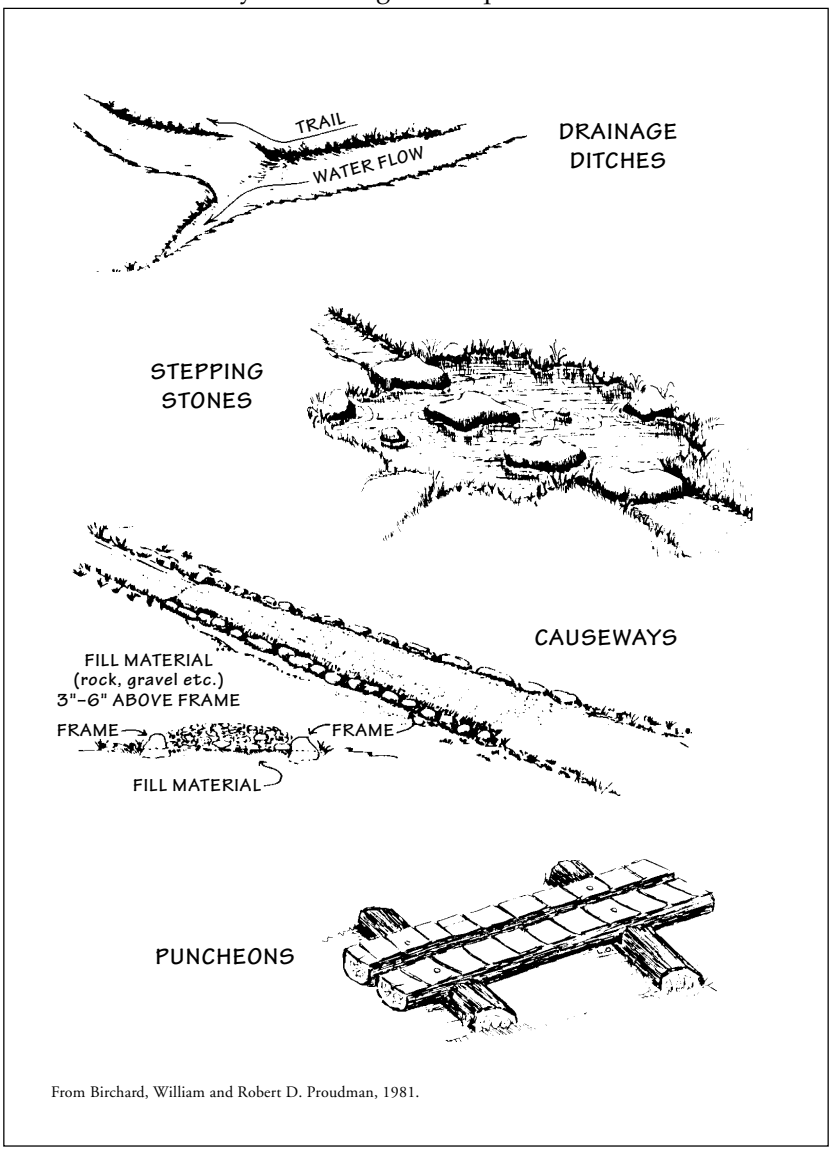
Stepping Stones – Where drainage ditches alone cannot adequately harden the treadway, then stepping stones should be placed across wet areas. These should be located close together, flat side up, and sunk low enough so that they do not rock.

Causeways – Causeways can be used to elevate the trail above the saturated terrain using rock, gravel or fill. The preferred method of construction is with gravel and rock that is placed inside a log frame. The fill is packed and mounded to a height of 3–6 inches above the frame. A drainage ditch is then dug parallel to and on both sides of the causeway.

Puncheons – Puncheons are used where there is little rock available or where the underlying soil is mucky or peaty. The simplest type of puncheon is a topped log puncheon, made with two stringers that form the treadway, set on two base logs that serve as mud sills.

Where a new trail traverses slopes greater than 10%, certain trail building techniques should be used to prevent trail widening and erosion. The major technique used is sidehill construction in which the trail is excavated so that water crosses the trail but does not run down the treadway at high velocities. Sidehilling is coupled with several additional techniques for erosion control such as shoring, cribbing, coweeta dips, bleeders, wonder bars, and steps. The process of sidehill trail construction and construction of the other erosion control techniques is somewhat complicated. For details refer to Chapter 8 of the Appalachian Trail Conference's publication entitled *Trail Design, Construction, and Maintenance* (1981).

FIGURE 4: Treadway Hardening Techniques



From Birchard, William and Robert D. Proudman, 1981.

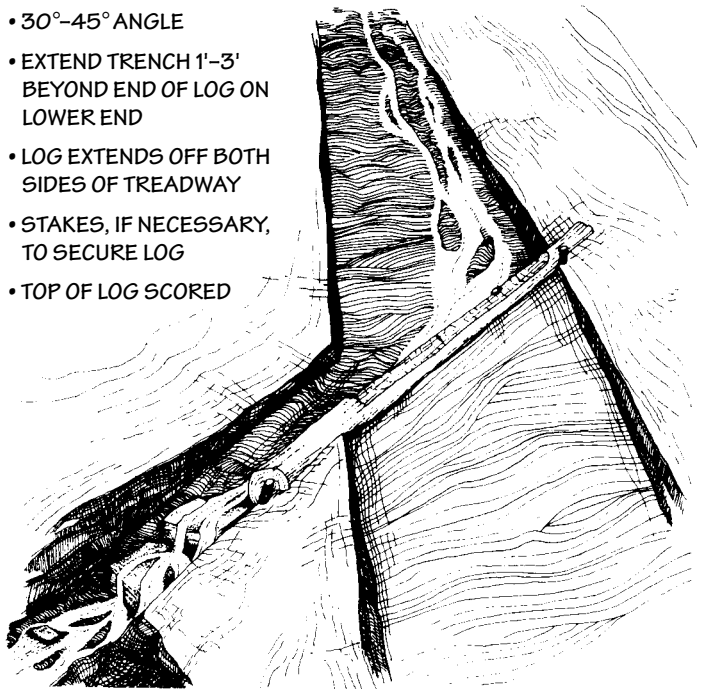
Waterbars

Waterbars, barriers that divert water off the treadway, are not only erosion control techniques, but are also erosion preventative techniques. In other words, trails should be waterbarred as a preventative measure, even if erosion is not yet evident. Waterbars should be installed on trails at every significant change in direction, at the top of downgrades, at points where water is entering trails, and at roughly the following intervals: every ±75 feet when the slope is 3–8%, every ±50 feet when the slope is 8–15%, and every ±25 feet when the slope is greater than 15%.

Waterbars can be constructed from any rot-resistant type of wood. Use logs with a minimum diameter of 6–8 inches at the small end, greater if water flow is heavy, and remove all bark. The length depends on the width of the trail; it should extend at least 1 ft. past the outside edge of the treadway on both sides.

Dig a trench across the trail at a 30˚–45˚ angle *(Figure 5).* The depth of the trench should be about the same as the diameter of the waterbar, enabling it to be almost flush with the trail on its downhill side once in place. The trench should be at least as long as the log, and in most cases greater. On the lower end, to ensure that the water is directed well off the trail and cannot return, the trench should be extended 1–3 feet beyond the end of the log, unless natural topography adequately channels water away from the trail. Make sure the trench is wide and free of rocks and roots.

FIGURE 13: Waterbars

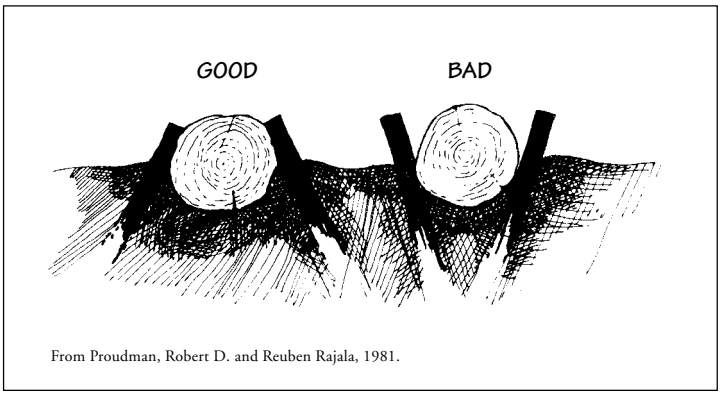

• 30°–45° ANGLE
• EXTEND TRENCH 1'–3' BEYOND END OF LOG ON LOWER END
• LOG EXTENDS OFF BOTH SIDES OF TREADWAY
• STAKES, IF NECESSARY, TO SECURE LOG
• TOP OF LOG SCORED

From Proudman, Robert D. and Reuben Rajala, 1981.

Place the log in the trench so that at least half of its diameter is below the treadway surface and it extends off both sides of the treadway. Neither water nor hikers should be able to pass around the bar. Seat the log solidly, if possible wedging it between rocks to make it stay in place. If the log is not completely stable, secure it by weighting the ends with heavy rocks or staking it in place with 3–5 stakes, one against the lower end and one or two on either side, placed near each end of the log, out of the main flow of traffic. Stakes on the uphill side of the bar should be notched into the log for added security and to minimize drag when water passes. To obtain stakes, cut 2–3-inch diameter

undesirable trees into 18-inch pieces with a bow saw. Drive the stakes at an angle, the top slanting over the log, so the stakes tend to pin the log to the ground *(Figure 6).* Pound the stakes until they are flush with the top of the log to prevent them from posing an obstacle or from becoming loose by being kicked. Saw off flush with the log any extra that cannot be driven.

FIGURE 6: Stakes



From Proudman, Robert D. and Reuben Rajala, 1981.

To finish the waterbar, score the top to provide a rough surface for hikers to step on. Grade the treadway above the bar gradually down into the trench, packing some soil underneath the log to prevent water from undercutting it. Pack all excavated soil and rock below the bar into a mound slightly higher than the top of the waterbar. With traffic it will pack and wear down flush with the top of the waterbar *(Figure 7).*

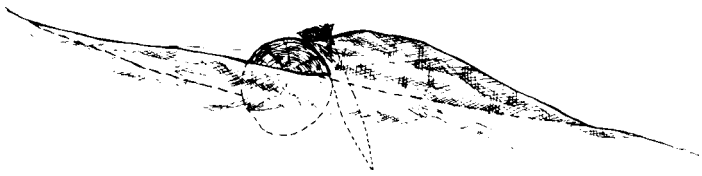
FIGURE 7: Waterbar Cross Section

From Proudman, Robert D. and Reuben Rajala, 1981.

The drainage ditch off the end of the waterbar should be broad (6–8 inches or more), free of roots, and the sides should be sloped. A narrow ditch or one with roots in it will clog easily; steep sides are apt to collapse. Where water flow is heavy or the bar directs water down a steep slope, runoff may erode the soil adjacent to the treadway. Where this is a problem, rocks should be placed in the channel to slow the water and make it drop its sediment.

Waterbars should be cleaned out annually in order to keep them working at maximum effectiveness. Deposited soil, leaf litter, and organic matter will clog waterbars, especially those which are not self-maintaining. Debris should be dug out on the upper side, with sediments being spread over the trail below the bar to backfill it *(Figure 8).* Any ditch that has filled in should be cleaned at the same time, using the debris for backfill as well.

FIGURE 8: Waterbar Maintenance

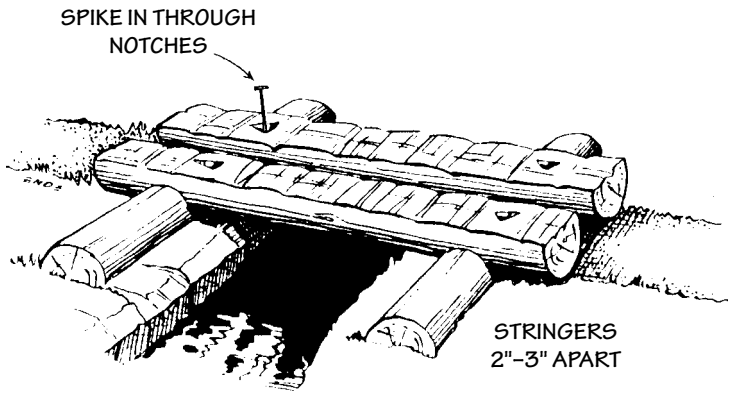


From Proudman, Robert D. and Reuben Rajala, 1981.

Drainage Swales, Stream Crossings and Boardwalks

For minor crossings of small streams and drainage swales, there is no need for construction of elaborate bridges. Natural stream crossings using stepping stones are ideal in this setting where the stream flow is generally low and there are not significant fluctuations in flow, except following major storm events. The stepping stones should be large and flat-topped. They should be placed approximately 2 ft. apart across the stream. Ideally, the bottom on which the stones are laid should be stone in order to prevent movement *(Figure 4).*

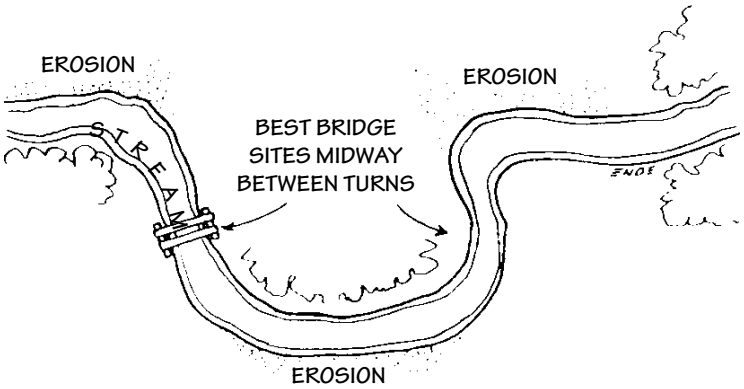
FIGURE 9: Stringer Bridge



From Birchard, William and Robert D. Proudman, 1981.

As an alternative to stepping stones, a simple bridge could be constructed of a single or double stringer with two base logs *(Figure 9).* The base logs should be placed on each bank above the flood level on a flat stone or ledge, secured with drift pins if possible. The stringer(s) should be secured to the base log on each end using 10 or 12-inch spikes or large bolts. Both the base logs and the stringers should be of rot-resistant wood such as hemlock, locust, white oak, or spruce from which all the bark has been removed. To facilitate construction, crossing sites for bridges should be selected where the banks are the same height and midway between turns *(Figure 10).* A handrail would be needed for safety only if the top of the stringer is more than 3 ft. above the stream *(Figure 11).* The stringer surface should be randomly scored to provide safer footing when wet.

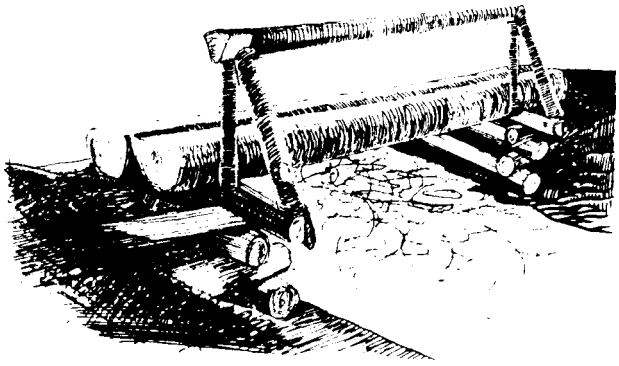
FIGURE 10: Bridge Siting



From Birchard, William and Robert D. Proudman, 1981.

Any new stream crossing by a bridge that involves a structure in the water will require a permit from the Pennsylvania Department of Environmental Protection, Bureau of Dam Safety, Obstruction, and Stormwater Management.

FIGURE 11: Two Stringer Bridge with Handrail



From Birchard, William and Robert D. Proudman, 1981.

Boardwalks are elevated post and decking structures that provide access to marsh and wetland ecosystems with minimal negative impacts. Boardwalks are usually constructed of wood and the foundation is usually a pier or wood post. If touching the ground or submerged in water, the posts most often are chemically treated with an oil-based or water-borne wood preservative such as creosote, pentachlorophenol, chromated copper arsenate, or zinc chloride. Most of these wood preservatives are toxic to the natural environment and can be harmful to human health. They do, however, add the necessary longevity and structural safety. Two alternatives are posts made from recycled plastics that do not release harmful chemicals into the ground or water system and galvanized steel helical piers and anchors. The recycled plastic post is either mechanically driven to the depth of firm soil or bedrock or secured in a concrete footing set in an excavated hole. The helical piers and anchors screw into the ground quickly, much the same as a wood screw goes into a piece of wood. Railings are an optional consideration for boardwalks that meander through wetland habitat. When the height of the decking above the ground exceeds 30 inches, rails are recommended.

Again, permits may be required for a boardwalk. The U.S. Army Corps of Engineers (Philadelphia District, 215-656-6729) requires a permit for any discharge of fill within wetlands.

Appendix L. Meadow Management

Historically, meadows occurred as breaks in the eastern deciduous forest resulting from disturbances such as fire, periodic flooding, insect infestation, and human clearing or because of site conditions (saturated soil or unusual geology). Most meadows existed as temporary ecosystems; without repeated disturbance, succession would eventually return the area to forest. As the Native American and then European populations increased, disturbance by fire, logging and agriculture maintained a shifting mosaic of meadow communities.

Most meadows in southeastern Pennsylvania have an agricultural past (old hayfields or pasture) and are dominated by exotic "cool-season" grasses[1] such as fescue, ryegrass, bluegrass, orchard grass and timothy.[2] These grasses as so named because they grow best during spring and fall. However, the grasses native to this region are mostly "warm-season" grasses,[3] which prosper during the summer months. Examples of warm season species include little bluestem , big bluestem, Indian grass, broomsedge and switchgrass.[4] Because they are native to this region, warm-season grasses are well adapted to the soils and climate. They can thrive on marginal soils and survive periods of low rainfall due to their deep fibrous root systems, which penetrate the soil to a depth of 5 to 15 feet.

Wildlife Benefits

Warm-season grasses are prime habitat for grassland birds because they are bunch grasses, in contrast to the sod-forming growth habit of cool-season grasses. This means that they grow upright with bare ground between clumps. This characteristic provides high-quality nesting sites and materials and allows grassland birds to move through the meadow more easily and better protected from avian predators in their search for food. The open space between clumps also provides space for wildflowers to become established.

In spring, ground-nesting birds utilize the cover afforded by the grasses to brood and rear their young. Flowers attract insects, which constitutes the most important element

[1] Cool-season grasses possess the most common photosynthetic pathway, known as C3 photosynthesis; new leaves emerge in late winter or early spring and they generally flower and set fruit in spring or early summer.
[2] Fescues — *Festuca arundinacea, F. elatior, F. longifolia, F. ovina, F. pratensis, F. rubra;* ryegrasses — *Lolium multiflorum, L. perenne;* bluegrasses — *Poa annua, P. pratensis, P. trivialis;* orchard grass — *Dactylis glomerata;* timothy — *Phleum pratense.*
[3] Warm-season grasses possess modified leaf anatomy and an unusual photosynthetic pathway, C4 photosynthesis; their emergence is often delayed until late spring or early summer and they generally flower and set fruit in late summer or fall.
[4] Little bluestem — *Schizachyrium scoparium;* big bluestem — *Andropogon gerardii;* Indian grass — *Sorghastrum nutans;* broomsedge — *Andropogon virginicus;* switchgrass — *Panicum virgatum.*

in the diet of young birds. During the autumn months, native wildflowers and grasses produce highly nutritious seeds. These are relished by a variety of songbirds and will attract many migrants that stop over on their long journey south. Throughout the winter, the upright grasses provide food and cover for the resident birds to help them survive the winter months.

Populations of grassland nesting birds such as bobolink, eastern meadowlark, grasshopper sparrow, savannah sparrow, upland sandpiper and northern bobwhite have declined drastically in recent years due to the loss of habitat from development and changes in farming practices, such as earlier mowing times and the extensive planting and cultivation of cool-season grasses.

Many butterfly species have also developed close relationships with native wildflowers. As our few remaining undisturbed habitats continue to be lost to development, many native plants are becoming increasingly rare. The implications for butterflies are dire; with the loss of their host plants, some butterfly species are inching closer toward extinction. Unless native wildflowers and butterfly habitats are restored, we can expect to see further declines in overall butterfly populations and continued losses of rare and endangered species.

Establishment

To maximize the ecological benefits (and reduce maintenance costs) it is recommended that large areas of turf and cool-season grass meadows be converted to warm-season grass and wildflower meadows. This is best achieved by eliminating the cool-season grasses, which are highly competitive, inhibiting the natural spread of native grasses and wildflowers. Cool-season grasses can be eliminated either by physically removing the sod (digging small areas; plowing and disking larger sites) or treating the area with an herbicide and seeding with a no-till drill. (Herbicides should not be used within 50 feet of a stream unless it is a formulation approved for aquatic use.) Spring (before the beginning of June) and late summer or early fall are the preferred times to plant meadows. If a rapid conversion to warm-season grasses is not an option for lack of funding or equipment, the landowner can encourage a gradual change from cool- to warm-season grass dominance through the timing of management (see below).

Management

Because a meadow is typically a temporary successional stage, it must be periodically disturbed to prevent woody vegetation from becoming established. This can be accomplished either by an annual mowing or prescribed burning every few years.

The frequency and timing of mowing has a dramatic affect on the composition of a meadow and its wildlife residents. Spring is the time of year when many wildlife species utilize meadows for reproduction. Mowing between the beginning of April and

late June, even though appealing to suburban esthetic sensibilities, is the worst time to mow. It removes nesting cover, destroys nests and eggs, and kills young birds and animals. Mowing between mid-July and late October does not leave enough of the growing season for the vegetation to renew itself and therefore provides little food and cover for wildlife until the following spring. Mowing at this time of year would be appropriate only in patches where noxious species such as Canada thistle or multiflora rose may be prevented from reproducing using this method.

There are two preferred times to mow meadows. Early July is desirable because it removes the browning stems and leaves of cool-season grasses, leaving more space for the warm-season species to grow, flower and provide habitat for the remainder of the year. This would be the best time to mow if the landowner wishes to gradually convert the meadow to warm-season grass dominance. Another good time to mow is in March. This will minimize the amount of time birds and animals lack cover. If environmental conditions such as wet soils prohibit early-spring mowing, winter mowing, when frost has hardened the ground, may be a good alternative. The most effective frequency and combination of these two mowing times will vary with different soil conditions, species composition, and other factors from site to site.

To maintain a meadow, it should be mowed either once or twice a year. Once-a-year mowing is sufficient to keep a meadow from reverting to woodland, but may not be sufficient to discourage woody seedlings, brambles, invasive vines and multiflora rose. Mowing more than twice a year will only encourage cool-season grass species. It is best to mow meadows when the ground is dry. They should be cut at a height of 6 to 8 inches during the growing season and 4 to 6 inches during the dormant season. Meadows must also be monitored for intrusion by invasive plants. Invasives in meadows may be eliminated by spot mowing, spot spraying or wick application of an appropriate herbicide, or manual or mechanical pulling.

To give the appearance that a meadow is intentional and managed, it is often beneficial to maintain a mowed turf swath around the public edges and consider incorporating a trail network. Well-maintained trails encourage people to get into the meadow and discover its beauty up close and first hand.

Another tool for managing meadows is prescribed fire. Fire was commonly used by Native Americans and early European settlers and selected fire-adapted species to dominate warm-season grass meadows. Periodic spring fires (every three years on average) will effectively discourage invasion by woody plants. Prescribed burning should be done only by well-trained personnel and in accordance with federal, state and local laws.

Appendix M. Woody Species Recommended for Planting in the Crum Woods

Tree, shrub and liana (woody vine) species native to the Piedmont and Coastal Plain in southeastern Pennsylvania are listed in the following three tables (source: Rhoads and Block 2000). Wetland status* is intended as a rough guide to the appropriate habitat type for planting (see codes at bottom of page). Other factors to consider in matching species to location include shade tolerance and soil pH. For example, dry oak-heath forests and dry oak-mixed hardwood forests tend to have more acidic soils than other forest types. Plants such as oak tree seedlings and shrub species in the heath family (Ericaceae) tolerate highly acidic soils but only certain members of these groups that are also drought-tolerant commonly occur in oak-dominated forests and are well suited to planting there. Information about native species' environmental preferences is available in standard horticultural texts (e.g., Bailey Hortorium. 1976; Dirr 1998; Cullina 2002; Fralish and Franklin 2002) or may be inferred from habitat notes in regional floral manuals (see Rhoads and Klein 1993; Rhoads and Block 2000) and plant community classifications (see Fike 1999).

Table M1. Tree species native to the Piedmont and Coastal Plain in Pennsylvania.

species	family	common name	wetland status*
Acer negundo	Aceraceae	box-elder	FAC+
Acer nigrum	Aceraceae	black maple	FACU
Acer pensylvanicum	Aceraceae	moosewood	FACU
Acer rubrum	Aceraceae	red maple	FAC
Acer saccharinum	Aceraceae	silver maple	FACW
Acer saccharum	Aceraceae	sugar maple	FACU
Aesculus flava	Hippocastanaceae	yellow buckeye	—
Aesculus glabra	Hippocastanaceae	Ohio buckeye	FACU+
Amelanchier arborea	Rosaceae	downy serviceberry	FAC–
Amelanchier canadensis	Rosaceae	shadbush	FAC
Aralia spinosa	Araliaceae	Hercules-club	FAC
Asimina triloba	Annonaceae	pawpaw	FACU+
Betula alleghaniensis	Betulaceae	yellow birch	FAC
Betula lenta	Betulaceae	black birch	FACU
Betula nigra	Betulaceae	river birch	FACW
Betula populifolia	Betulaceae	gray birch	FAC
Carpinus caroliniana	Betulaceae	American hornbeam	FAC

(continued on next page)

*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Carya cordiformis	Juglandaceae	bitternut hickory	FACU+
Carya glabra	Juglandaceae	pignut hickory	FACU–
Carya laciniosa	Juglandaceae	shellbark hickory	FAC
Carya ovalis	Juglandaceae	sweet pignut hickory	—
Carya ovata	Juglandaceae	shagbark hickory	FACU
Carya tomentosa	Juglandaceae	mockernut hickory	FACU
Castanea dentata	Fagaceae	American chestnut	—
Castanea pumila	Fagaceae	chinquapin	—
Celtis occidentalis	Ulmaceae	hackberry	FACU
Celtis tenuifolia	Ulmaceae	dwarf hackberry	—
Cercis canadensis	Caesalpiniaceae	redbud	—
Chamaecyparis thyoides	Cupressaceae	Atlantic white-cedar	OBL
Chionanthus virginicus	Oleaceae	fringe-tree	FAC+
Cornus alternifolia	Cornaceae	alternate-leaved dogwood	—
Cornus florida	Cornaceae	flowering dogwood	FACU–
Crataegus calpodendron	Rosaceae	pear hawthorn	—
Crataegus coccinea	Rosaceae	red-fruited hawthorn	—
Crataegus crus-galli	Rosaceae	cockspur hawthorn	FACU
Crataegus flabellata	Rosaceae	fanleaf hawthorn	—
Crataegus intricata	Rosaceae	Biltmore hawthorn	—
Crataegus mollis	Rosaceae	downy hawthorn	FACU
Crataegus pruinosa	Rosaceae	frosted hawthorn	—
Crataegus punctata	Rosaceae	dotted hawthorn	—
Crataegus rotundifolia	Rosaceae	fireberry hawthorn	—
Crataegus succulenta	Rosaceae	long-spined hawthorn	—
Diospyros virginiana	Ebenaceae	persimmon	FAC–
Fagus grandifolia	Fagaceae	American beech	FACU
Fraxinus americana	Oleaceae	white ash	FACU
Fraxinus nigra	Oleaceae	black ash	FACW
Fraxinus pennsylvanica	Oleaceae	red ash	FACW
Gleditsia triacanthos	Caesalpiniaceae	honey-locust	FAC–
Gymnocladus dioica	Caesalpiniaceae	Kentucky coffee-tree	—
Ilex opaca	Aquifoliaceae	American holly	FACU

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*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Juglans cinerea	Juglandaceae	butternut	FACU+
Juglans nigra	Juglandaceae	black walnut	FACU
Juniperus virginiana	Cupressaceae	eastern red-cedar	FACU
Liquidambar styraciflua	Hamamelidaceae	sweetgum	FAC
Liriodendron tulipifera	Magnoliaceae	tuliptree	FACU
Magnolia acuminata	Magnoliaceae	cucumber-tree	—
Magnolia tripetala	Magnoliaceae	umbrella-tree	FACU
Magnolia virginiana	Magnoliaceae	sweet-bay magnolia	FACW+
Malus coronaria	Rosaceae	sweet crabapple	—
Morus rubra	Moraceae	red mulberry	FACU
Nyssa sylvatica	Nyssaceae	sourgum	FAC
Ostrya virginiana	Betulaceae	hop-hornbeam	FACU–
Oxydendrum arboreum	Ericaceae	sourwood	—
Picea mariana	Pinaceae	black spruce	FACW–
Pinus echinata	Pinaceae	short-leaf pine	—
Pinus pungens	Pinaceae	Table Mountain pine	—
Pinus resinosa	Pinaceae	red pine	FACU
Pinus rigida	Pinaceae	pitch pine	FACU
Pinus strobus	Pinaceae	eastern white pine	FACU
Pinus virginiana	Pinaceae	Virginia pine	—
Platanus occidentalis	Platanaceae	sycamore	FACW–
Populus balsamifera	Salicaceae	balsam poplar	FACW
Populus deltoides	Salicaceae	eastern cottonwood	FACU–
Populus grandidentata	Salicaceae	bigtooth aspen	FACU–
Populus tremuloides	Salicaceae	quaking aspen	—
Prunus americana	Rosaceae	wild plum	FACU–
Prunus angustifolia	Rosaceae	Chickasaw plum	—
Prunus pensylvanica	Rosaceae	pin cherry	FACU–
Prunus serotina	Rosaceae	wild black cherry	FACU
Prunus virginiana	Rosaceae	choke cherry	FACU
Quercus alba	Fagaceae	white oak	FACU
Quercus bicolor	Fagaceae	swamp white oak	FACW+
Quercus coccinea	Fagaceae	scarlet oak	—
Quercus falcata	Fagaceae	southern red oak	FACU–

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*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Quercus imbricaria	Fagaceae	shingle oak	FAC
Quercus macrocarpa	Fagaceae	bur oak	FAC–
Quercus marilandica	Fagaceae	blackjack oak	—
Quercus montana	Fagaceae	chestnut oak	FACW
Quercus muhlenbergii	Fagaceae	yellow oak	UPL
Quercus palustris	Fagaceae	pin oak	FACW
Quercus phellos	Fagaceae	willow oak	FAC+
Quercus rubra	Fagaceae	northern red oak	FACU–
Quercus stellata	Fagaceae	post oak	UPL
Quercus velutina	Fagaceae	black oak	—
Robinia pseudoacacia†	Fabaceae	black locust†	FACU–
Salix nigra	Salicaceae	black willow	FACW+
Sassafras albidum	Lauraceae	sassafras	FACU–
Tilia americana	Tiliaceae	basswood	FACU
Toxicodendron vernix†	Anacardiaceae	poison sumac†	OBL
Tsuga canadensis	Pinaceae	eastern hemlock	FACU
Ulmus americana	Ulmaceae	American elm	FACW–
Ulmus rubra	Ulmaceae	slippery elm	FAC–
Viburnum prunifolium	Caprifoliaceae	black-haw	FACU

Table M2. Shrub species native to the Piedmont and Coastal Plain in Pennsylvania

species	family	common name	wetland status*
Acer spicatum	Aceraceae	mountain maple	FACU–
Alnus serrulata	Betulaceae	smooth alder	OBL
Amelanchier canadensis	Rosaceae	shadbush	FAC
Amelanchier intermedia	Rosaceae	shadbush	FACW
Amelanchier obovalis	Rosaceae	coastal juneberry	FACU
Amelanchier stolonifera	Rosaceae	low juneberry	FACU
Amorpha fruticosa	Fabaceae	false-indigo	FACW
Aronia arbutifolia	Rosaceae	red chokeberry	FACW
Aronia melanocarpa	Rosaceae	black chokeberry	FAC

(continued on next page)

† not recommended for planting
*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Aronia prunifolia	Rosaceae	purple chokeberry	FACW
Baccharis halimifolia	Asteraceae	groundsel-tree	FACW
Calycanthus floridus var. *laevigatus*	Calycanthaceae	Carolina allspice	—
Ceanothus americanus	Rhamnaceae	New Jersey tea	—
Cephalanthus occidentalis	Rubiaceae	buttonbush	OBL
Clethra alnifolia	Clethraceae	sweet pepperbush	FAC+
Comptonia peregrina	Myricaceae	sweet-fern	—
Cornus amomum ssp. *amomum*	Cornaceae	kinnikinik	FACW
Cornus racemosa	Cornaceae	silky dogwood	FAC–
Cornus rugosa	Cornaceae	round-leaved dogwood	—
Cornus sericea	Cornaceae	red-osier dogwood	FACW+
Corylus americana	Betulaceae	American filbert	FACU–
Corylus cornuta	Betulaceae	beaked hazelnut	FACU–
Crataegus calpodendron	Rosaceae	pear hawthorn	—
Crataegus coccinea	Rosaceae	red-fruited hawthorn	—
Crataegus crus-galli	Rosaceae	cockspur hawthorn	FACU
Crataegus flabellata	Rosaceae	fanleaf hawthorn	—
Crataegus intricata	Rosaceae	Biltmore hawthorn	—
Crataegus pruinosa	Rosaceae	frosted hawthorn	—
Crataegus rotundifolia	Rosaceae	fireberry hawthorn	—
Crataegus uniflora	Rosaceae	one-fruited hawthorn	—
Decodon verticillatus	Lythraceae	water-willow	OBL
Diervilla lonicera	Caprifoliaceae	bush-honeysuckle	—
Dirca palustris	Thymelaeaceae	leatherwood	FAC
Epigaea repens	Ericaceae	trailing-arbutus	—
Euonymus americanus	Celastraceae	hearts-a-bursting	FAC
Euonymus atropurpureus	Celastraceae	burning-bush	FACU
Gaultheria procumbens	Ericaceae	teaberry	FACU
Gaylussacia baccata	Ericaceae	black huckleberry	FACU
Gaylussacia dumosa	Ericaceae	dwarf huckleberry	FAC
Gaylussacia frondosa	Ericaceae	dangleberry	FAC
Hamamelis virginiana	Hamamelidaceae	witch-hazel	FACU+
Hydrangea arborescens	Hydrangeaceae	sevenbark	FACU

(continued on next page)

*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Hypericum crux-andreae	Clusiaceae	St.Peter's-wort	FACU
Hypericum densiflorum	Clusiaceae	bushy St.John's-wort	FAC+
Hypericum prolificum	Clusiaceae	shrubby St. John's-wort	FACU
Ilex glabra	Aquifoliaceae	inkberry	FACW–
Ilex laevigata	Aquifoliaceae	smooth winterberry	OBL
Ilex montana	Aquifoliaceae	mountain holly	—
Ilex verticillata	Aquifoliaceae	winterberry	FACW+
Itea virginica	Grossulariaceae	tassel-white	OBL
Iva frutescens ssp. *oraria*	Asteraceae	marsh-elder	FACW+
Juniperus communis	Cupressaceae	common juniper	—
Kalmia angustifolia	Ericaceae	sheep-laurel	FAC
Kalmia latifolia	Ericaceae	mountain-laurel	FACU
Leucothoe racemosa	Ericaceae	fetter-bush	FACW
Lindera benzoin	Lauraceae	spicebush	FACW–
Lonicera canadensis	Caprifoliaceae	fly honeysuckle	FACU
Lonicera dioica var. *diocia*	Caprifoliaceae	mountain honeysuckle	FACU
Lonicera oblongifolia	Caprifoliaceae	swamp fly honeysuckle	OBL
Lyonia ligustrina	Ericaceae	maleberry	FACW
Lyonia mariana	Ericaceae	staggerbush	FAC–
Myrica pensylvanica	Myricaceae	bayberry	FAC
Nemopanthus mucronatus	Aquifoliaceae	mountain holly	OBL
Phoradendron leucarpum	Viscaceae	Christmas mistletoe	—
Physocarpus opulifolius	Rosaceae	ninebark	FACW–
Prunus americana	Rosaceae	wild plum	FACU–
Prunus angustifolia	Rosaceae	Chickasaw plum	—
Prunus maritima	Rosaceae	beach plum	NC
Prunus pumila var. *depressa*	Rosaceae	sand cherry	NC
Prunus virginiana	Rosaceae	choke cherry	FACU
Ptelea trifoliata	Rutaceae	hoptree	FAC
Quercus ilicifolia	Fagaceae	scrub oak	—
Quercus prinoides	Fagaceae	dwarf chestnut oak	—
Rhamnus alnifolia	Rhamnaceae	alder-leaved buckthorn	OBL
Rhamnus lanceolata	Rhamnaceae	lanceolate buckthorn	—

(continued on next page)

*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Rhododendron arborescens	Ericaceae	smooth azalea	FAC
Rhododendron atlanticum	Ericaceae	dwarf azalea	FAC
Rhododendron calendulaceum	Ericaceae	flame azalea	—
Rhododendron maximum	Ericaceae	rosebay	FAC
Rhododendron periclymenoides	Ericaceae	pinxter-flower	FAC
Rhododendron prinophyllum	Ericaceae	mountain azalea	FAC
Rhododendron viscosum	Ericaceae	swamp azalea	FACW+
Rhus copallina var. *copallina*	Anacardiaceae	shining sumac	—
Rhus glabra	Anacardiaceae	smooth sumac	—
Rhus typhina	Anacardiaceae	staghorn sumac	—
Ribes americanum	Grossulariaceae	wild black currant	FACW
Ribes cynosbati	Grossulariaceae	prickly gooseberry	—
Ribes hirtellum	Grossulariaceae	northern wild gooseberry	FAC
Ribes missouriense	Grossulariaceae	Missouri gooseberry	—
Ribes rotundifolium	Grossulariaceae	wild gooseberry	—
Rosa blanda	Rosaceae	meadow rose	NR
Rosa carolina var. *carolina*	Rosaceae	pasture rose	UPL
Rosa palustris	Rosaceae	swamp rose	OBL
Rosa virginiana	Rosaceae	wild rose	FAC
Rubus allegheniensis	Rosaceae	common blackberry	FACU–
Rubus cuneifolius	Rosaceae	sand blackberry	UPL
Rubus occidentalis	Rosaceae	black-cap	—
Rubus odoratus	Rosaceae	purple-flowering raspberry	—
Rubus pensilvanicus	Rosaceae	blackberry	—
Rubus pubescens	Rosaceae	dwarf blackberry	FACW
Rubus setosus	Rosaceae	bristly blackberry	FACW
Salix bebbiana	Salicaceae	long-beaked willow	FACW
Salix discolor	Salicaceae	pussy willow	FACW
Salix eriocephala	Salicaceae	diamond willow	FACW+
Salix exigua	Salicaceae	sandbar willow	OBL
Salix humilis var. *humilis*	Salicaceae	upland willow	FACU
Salix lucida ssp. *lucida*	Salicaceae	shining willow	FACW
Salix myricoides var. *myricoides*	Salicaceae	broad-leaved willow	FAC
Salix petiolaris	Salicaceae	slender willow	FACW+

(continued on next page)

*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Salix sericea	Salicaceae	silky willow	OBL
Sambucus canadensis	Caprifoliaceae	American elder	FACW
Sambucus racemosa var. *pubens*	Caprifoliaceae	red-berried elder	FACU
Spiraea alba	Rosaceae	meadow-sweet	FACW+
Spiraea latifolia	Rosaceae	meadow-sweet	FAC+
Spiraea tomentosa	Rosaceae	hardhack	FACW–
Staphylea trifolia	Staphyleaceae	bladdernut	FAC
Symphoricarpos albus var. *albus*	Caprifoliaceae	snowberry	FACU–
Symphoricarpos orbiculatus	Caprifoliaceae	coralberry	UPL
Taxus canadensis	Taxaceae	American yew	FAC
Vaccinium angustifolium	Ericaceae	low sweet blueberry	FACU–
Vaccinium corymbosum	Ericaceae	highbush blueberry	FACW–
Vaccinium macrocarpon	Ericaceae	cranberry	OBL
Vaccinium myrtilloides	Ericaceae	sour-top blueberry	FAC
Vaccinium pallidum	Ericaceae	lowbush blueberry	—
Vaccinium stamineum	Ericaceae	deerberry	FACU–
Viburnum acerifolium	Caprifoliaceae	maple-leaved viburnum	—
Viburnum cassinoides	Caprifoliaceae	witherod	FACW
Viburnum dentatum	Caprifoliaceae	southern arrow-wood	FAC
Viburnum lentago	Caprifoliaceae	nannyberry	FAC
Viburnum nudum	Caprifoliaceae	possum-haw	OBL
Viburnum prunifolium	Caprifoliaceae	black-haw	FACU
Viburnum rafinesquianum	Caprifoliaceae	downy arrow-wood	—
Viburnum recognitum	Caprifoliaceae	northern arrow-wood	FACW–
Viburnum trilobum	Caprifoliaceae	highbush-cranberry	FACW
Vitis rupestris	Vitaceae	sand grape	UPL
Zanthoxylum americanum	Rutaceae	prickly-ash	FACU

Table M3. Liana (woody vine) species native to the Piedmont and Coastal Plain in Pennsylvania

species	family	common name	wetland status*
Campsis radicans	Bignoniaceae	trumpet-vine	FAC
Celastrus scandens	Celastraceae	American bittersweet	FACU–

(continued on next page)

*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

species	family	common name	wetland status*
Lonicera sempervirens	Caprifoliaceae	trumpet honeysuckle	FACU
Menispermum canadense	Menispermaceae	moonseed	FACU
Parthenocissus inserta	Vitaceae	grape woodbine	—
Parthenocissus quinquefolia	Vitaceae	Virginia-creeper	FACU
Rubus enslenii	Rosaceae	southern dewberry	FACU
Rubus flagellaris	Rosaceae	prickly dewberry	FACU
Rubus hispidus	Rosaceae	swamp dewberry	FACW
Rubus recurvicaulis	Rosaceae	dewberry	FACU
Smilax glauca	Smilacaceae	catbrier	FACU
Smilax hispida	Smilacaceae	bristly greenbrier	—
Smilax rotundifolia†	Smilacaceae	greenbrier†	FAC
Toxicodendron radicans†	Anacardiaceae	poison-ivy†	FAC
Vitis aestivalis†	Vitaceae	summer grape†	FACU
Vitis labrusca†	Vitaceae	fox grape†	FACU
Vitis riparia†	Vitaceae	frost grape†	FACW
Vitis vulpina†	Vitaceae	frost grape†	FAC
Wisteria frutescens	Fabaceae	American wisteria	FACW–

† not recommended for planting

*Estimated probability of occurrence in wetlands under natural conditions (Reed 1988): OBL, > 99%; FACW, 67 – 99%; FAC, 34 – 66%; FACU, 1 – 33%; UPL, < 1%; +, higher end of frequency range; –, lower end of frequency range.

Appendix N. Crum Woods Vegetation Mapping Methodology

Crum Woods plant communities were mapped (Figures 4 and 5) by a plant community ecologist with over 25 years' experience in vegetation mapping in the mid-Atlantic and Great Lakes regions (Roger Latham), using a qualitative approach, that is, without collecting numerical data on the composition, abundance and distribution of species. This appendix presents a brief outline of the methods used.

(1) Acquired three sets of aerial photographs of the entire site, each with 60% overlap between adjacent images, for stereo interpretation:

(a) High-resolution false-color infrared aerial photographs taken 10 March 1991, scale 1:40,000
(b) High-resolution black-and-white aerial photographs taken 29 December 1994, scale 1:20,000
(c) Black-and-white aerial photographs taken 1 December 1937, scale 1:20,000

(2) Completed preliminary photointerpretation using a Topcon Model 3 mirror stereoscope with 1.8 × and 3 × magnification. A stereoscope enables the interpreter to see land, vegetation, buildings, and other features in an exaggerated three-dimensional view. Interpretation involves bringing field experience and prior photointerpretation experience to bear in minutely examining the features in each small part of the image, including color (hue, saturation and value), pattern, three-dimensional texture, shadows, topographic position, slope, solar aspect, and context. In all of the photographs used, objects as small as individual trees could be discerned where situated in contrasting surroundings.

(a) Identified internally uniform vegetation polygons (preliminary vegetation mapping units), which numbered approximately 150 (average size about 1.5 acres/0.6 ha, ranging from less than 0.1 acre/0.04 ha to nearly 10 acres/4 ha).
(b) Delineated preliminary vegetation mapping units onto enlarged photocopies of alternate images along each flight path, to use as a guide to "ground-truthing" in the field.

(3) Ground-truthed all mapping units.

(a) Recorded the dominant species (see footnote, page 21) and noteworthy subordinate species while walking through each preliminary vegetation mapping unit, choosing the path as required to make visual contact with the entire area of the unit.
(b) In forest and woodland units, noted density and predominant species of three vegetation layers beneath the dominant tree canopy: (i) subcanopy (small trees), (ii) understory shrubs, and (iii) ground-layer herbaceous plants. Visited forest and woodland units twice, in spring and in late summer or early fall, in order to inventory vernal ephemeral flowering plants as well as those in flower or fruit late in the growing season.

(c) Noted locations of potential hazards and other problem spots.
(d) Searched for instances in which the boundaries drawn around preliminary vegetation mapping units did not accurately reflect on-the-ground observations, and redrew boundaries as needed.
(e) Used global positioning system (G.P.S.) to accurately locate features not visible in aerial photographs, including trails and the leading edges of invasive species' advancing fronts.

(4) Developed a vegetation classification system based on prevailing principles of community classification (Grossman et al. 1998) and tailored to maximize its utility as an aid in addressing current management concerns within the Crum Woods and in guiding future management to meet the pedagogical, ecological, and recreational needs of the Swarthmore College community. *Terrestrial and Palustrine Plant Communities of Pennsylvania* (Fike 1999) was used as a template for classifying communities dominated by native species and indigenous natural processes (see Table N1).

(5) Finalized a 2003 baseline plant communities map by revising preliminary vegetation mapping units based on information gathered while ground-truthing. Final vegetation mapping units, which numbered approximately 160 (average size about 1.4 acre/0.57 ha, range 0.05 to 9.0 acres/0.02 to 3.6 ha), were digitized in the computerized geographic information system (G.I.S.) at Natural Lands Trust for use with other existing and prospective data layers. The following attributes and categories within each attribute were included for each final vegetation mapping unit to make possible the creation of a variety of maps highlighting different plant community characteristics:

- **system**: terrestrial, palustrine, aquatic (defined in Section 1.2, page 21)
- **physiognomy**: forest, woodland, shrubland, herbaceous community (defined in Section 1.2.1, page 22)
- **origin and influence**: mostly indigenous, mostly cultural (defined in Section 1.2, page 21)
- **forest/woodland canopy type**: broadleaf, conifer-broadleaf, conifer, sparse or no trees
- **stability**: persistent, successional, artificially maintained
- **forest subcanopy**: mostly native, mixed, mostly Norway maple, mostly other introduced tree species, none
- **shrub layer density or non-forest/non-thicket ground layer type**: dense, intermediate, sparse, absent, turf, meadow
- **shrub layer origin**: mostly native, mixed, mostly introduced (defined in Section 1.2.1.4, pages 25, 26)

(6) Using photointerpretation only, delineated the area in forest cover in 1937 for evaluation of subsequent rates of loss in total forested area and functioning forest interior (see Section 3.2.1).

Table N1. Terrestrial and palustrine communities/land cover types, organized by the top three attributes. Community types of mainly indigenous origin and influence are from Fike (1999).

origin	system	physiognomy	community/land cover type
mainly indigenous			
	terrestrial		
		forest	
			Dry oak-heath forest
			Dry oak-mixed hardwood forest
			Hemlock (white pine)-red oak-mixed hardwood forest
			Red oak-mixed hardwood forest
			Tuliptree-beech-maple forest
	palustrine		
		forest	
			Sycamore-(river birch)-boxelder floodplain forest
		woodland	
			Red maple-mixed shrub palustrine woodland
			Sycamore-(river birch)-boxelder floodplain woodland
		shrubland	
			Black willow scrub/shrub wetland
		herbaceous	
			Mixed forb marsh
mainly cultural			
	terrestrial		
		forest	
			Forest (upland) with strong presence of introduced species
			Conifer plantation/planted forest
		woodland	
			Woodland (upland) with strong presence of introduced species
			Mowed (upland) woodland
		shrubland	
			Successional (upland) thicket

(continued on next page)

Table N1 (continued)

origin	system	physiognomy	community/land cover type
	terrestrial (continued)		
		herbaceous	
			Landscaped area
			Upland mowed turf
			Herb-dominated old field/road cut
	palustrine		
		forest	
			Wet forest with strong presence of introduced species
		woodland	
			Wet woodland with strong presence of introduced species
			Wet mowed woodland
		herbaceous	
			Wet meadow
			Wet mowed turf
	no vegetation		
			Pavement

Crum Woods

Conservation and Stewardship Plan

Swarthmore College
Delaware County, Pennsylvania

Fig. 1 Location
(With 1992 Aerial Photograph)

Compiled By: DCR Date: 12/16/03

Notes:

1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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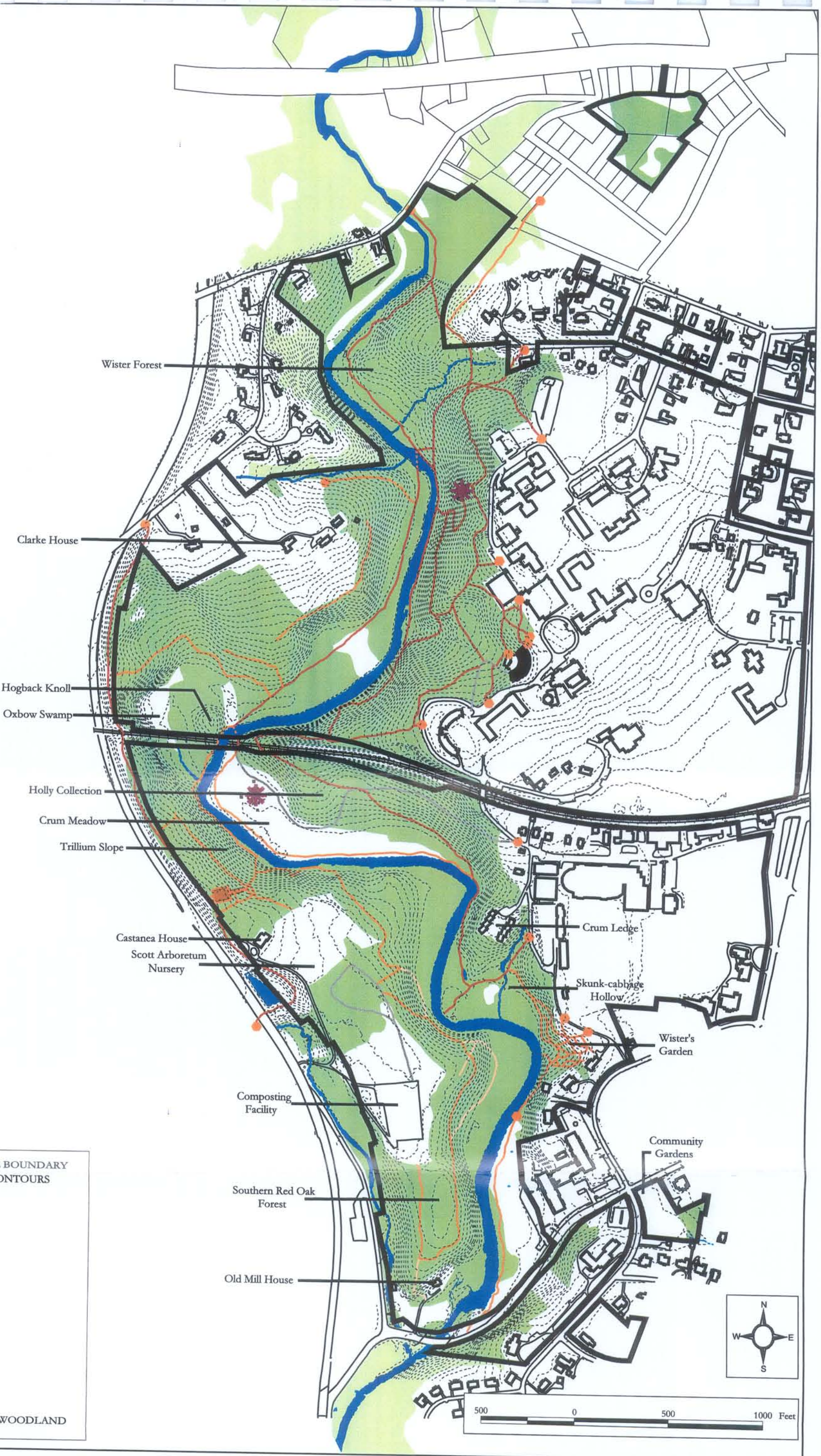
1031 Palmers Mill Road
Media, PA 19063
610-353-5587
www.natlands.org



Crum Woods
Conservation and Stewardship Plan
Swarthmore College
Delaware County, Pennsylvania

Fig. 2 Site Plan of Campus Woods

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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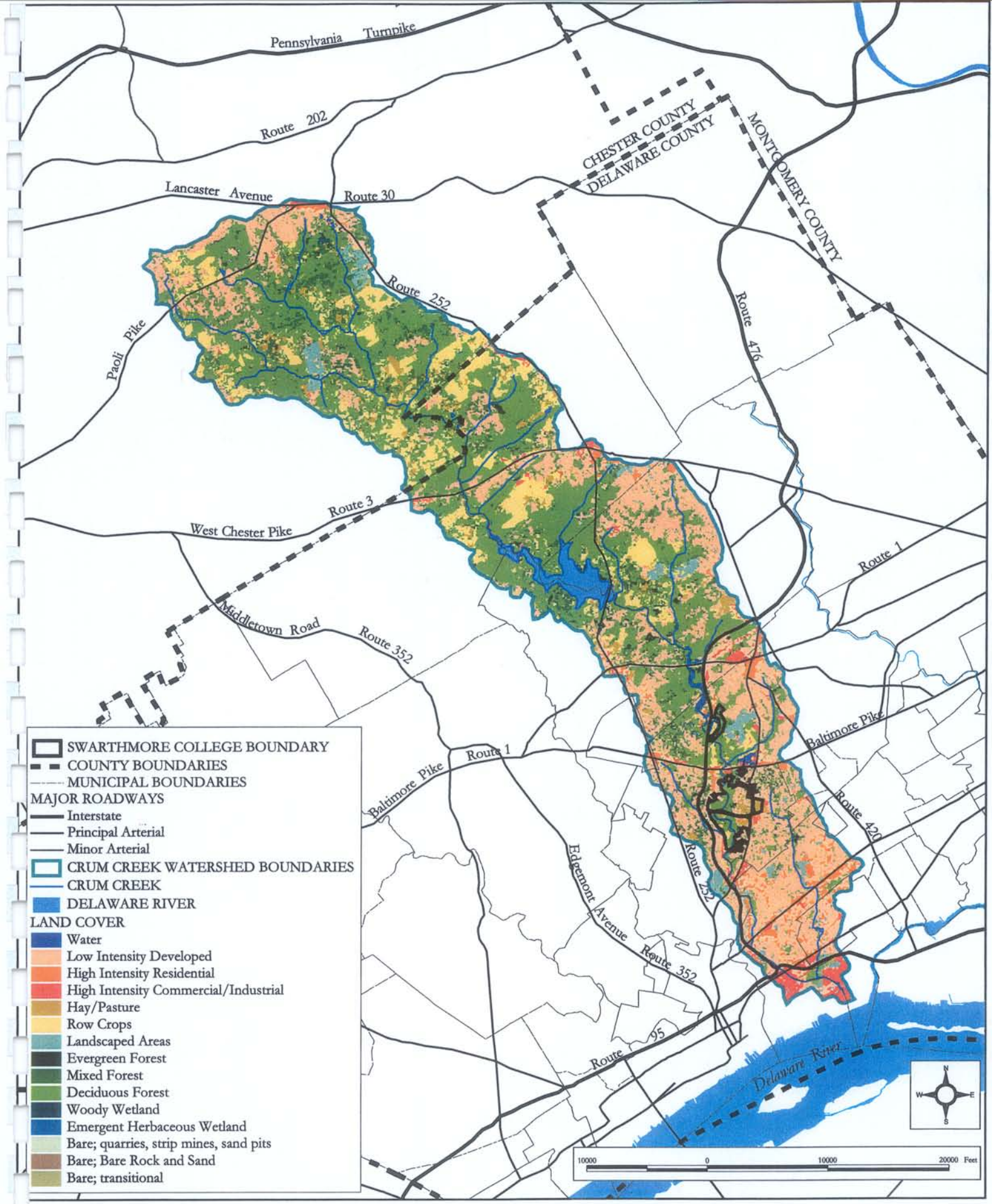

Crum Woods
Conservation and Stewardship Plan
Swarthmore College
Delaware County, Pennsylvania

Fig. 3 Crum Creek Watershed Land Cover

Compiled By: DCK Date: 12/16/05
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum bengs received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Allgator Rock, garden rain, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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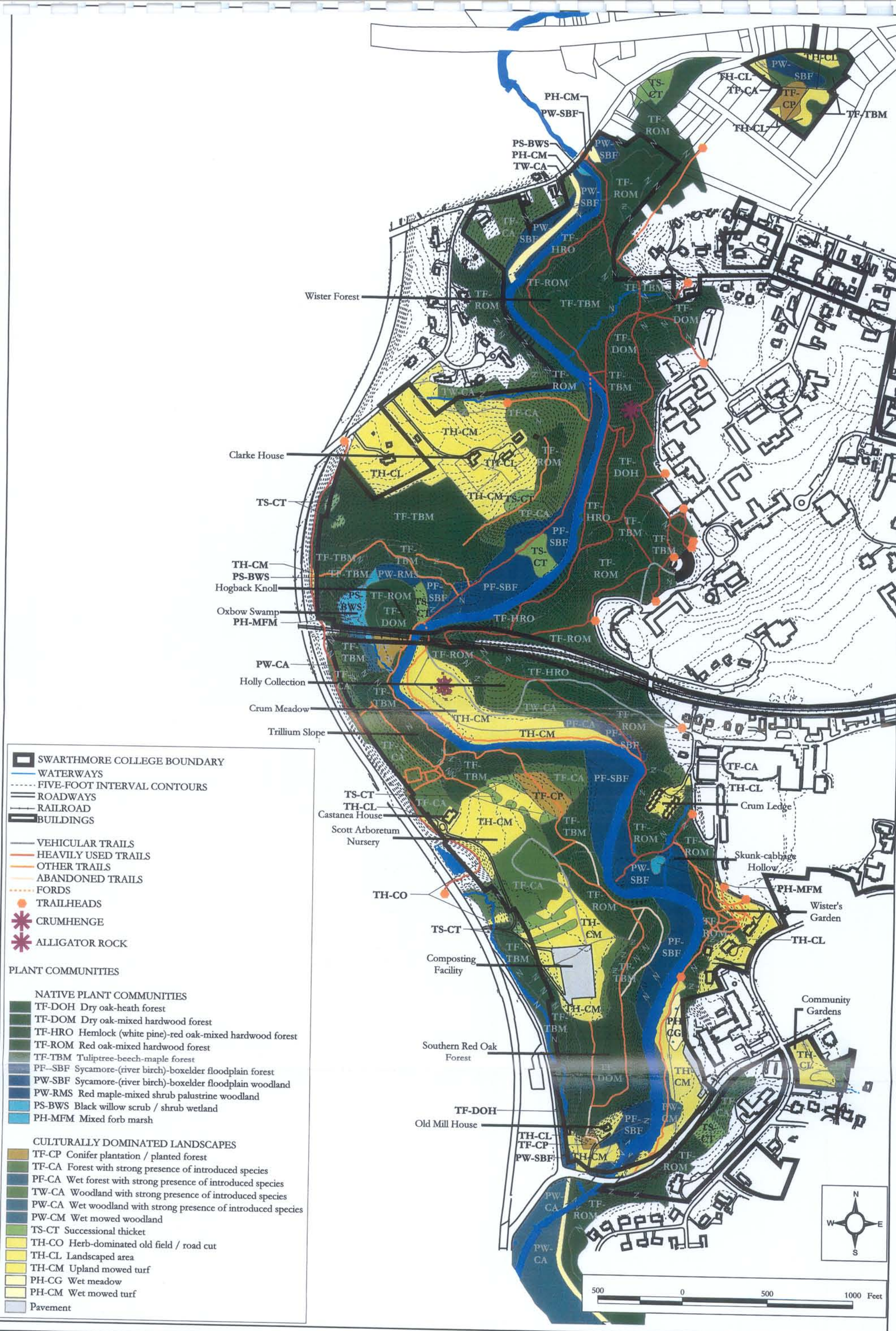

- SWARTHMORE COLLEGE BOUNDARY
- WATERWAYS
- FIVE-FOOT INTERVAL CONTOURS
- ROADWAYS
- RAILROAD
- BUILDINGS
- VEHICULAR TRAILS
- HEAVILY USED TRAILS
- OTHER TRAILS
- ABANDONED TRAILS
- FORDS
- TRAILHEADS
- CRUMHENGE
- ALLIGATOR ROCK

PLANT COMMUNITIES

NATIVE PLANT COMMUNITIES
- TF-DOH Dry oak-heath forest
- TF-DOM Dry oak-mixed hardwood forest
- TF-HRO Hemlock (white pine)-red oak-mixed hardwood forest
- TF-ROM Red oak-mixed hardwood forest
- TF-TBM Tuliptree-beech-maple forest
- PF--SBF Sycamore-(river birch)-boxelder floodplain forest
- PW-SBF Sycamore-(river birch)-boxelder floodplain woodland
- PW-RMS Red maple-mixed shrub palustrine woodland
- PS-BWS Black willow scrub / shrub wetland
- PH-MFM Mixed forb marsh

CULTURALLY DOMINATED LANDSCAPES
- TF-CP Conifer plantation / planted forest
- TF-CA Forest with strong presence of introduced species
- PF-CA Wet forest with strong presence of introduced species
- TW-CA Woodland with strong presence of introduced species
- PW-CA Wet woodland with strong presence of introduced species
- PW-CM Wet mowed woodland
- TS-CT Successional thicket
- TH-CO Herb-dominated old field / road cut
- TH-CL Landscaped area
- TH-CM Upland mowed turf
- PH-CG Wet meadow
- PH-CM Wet mowed turf
- Pavement

Crum Woods
Conservation and Stewardship Plan
Swarthmore College
Delaware County, Pennsylvania

Fig. 4 Plant Communities
Campus Woods

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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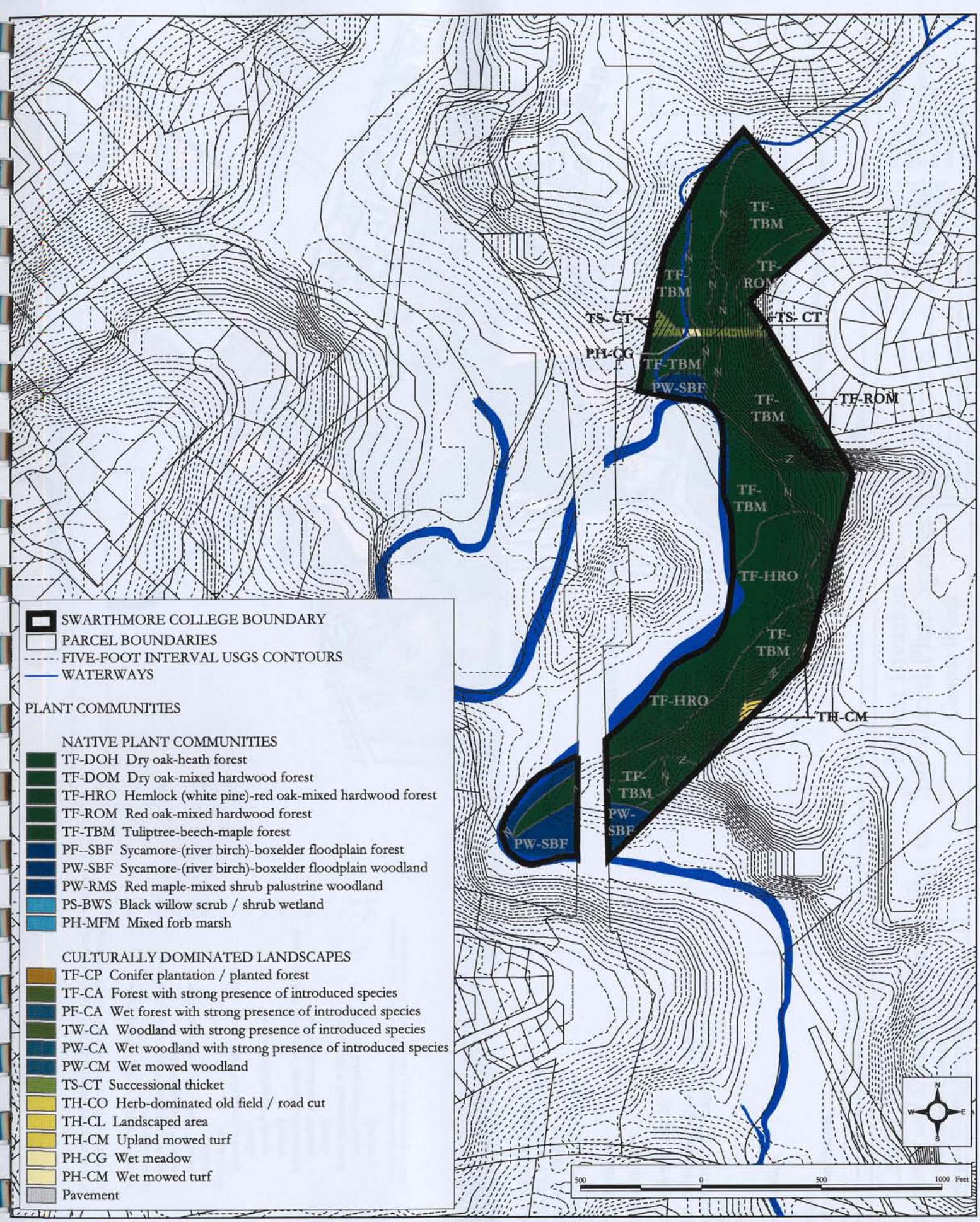

SWARTHMORE COLLEGE BOUNDARY
PARCEL BOUNDARIES
FIVE-FOOT INTERVAL USGS CONTOURS
WATERWAYS

PLANT COMMUNITIES

NATIVE PLANT COMMUNITIES
- TF-DOH Dry oak-heath forest
- TF-DOM Dry oak-mixed hardwood forest
- TF-HRO Hemlock (white pine)-red oak-mixed hardwood forest
- TF-ROM Red oak-mixed hardwood forest
- TF-TBM Tuliptree-beech-maple forest
- PF--SBF Sycamore-(river birch)-boxelder floodplain forest
- PW-SBF Sycamore-(river birch)-boxelder floodplain woodland
- PW-RMS Red maple-mixed shrub palustrine woodland
- PS-BWS Black willow scrub / shrub wetland
- PH-MFM Mixed forb marsh

CULTURALLY DOMINATED LANDSCAPES
- TF-CP Conifer plantation / planted forest
- TF-CA Forest with strong presence of introduced species
- PF-CA Wet forest with strong presence of introduced species
- TW-CA Woodland with strong presence of introduced species
- PW-CA Wet woodland with strong presence of introduced species
- PW-CM Wet mowed woodland
- TS-CT Successional thicket
- TH-CO Herb-dominated old field / road cut
- TH-CL Landscaped area
- TH-CM Upland mowed turf
- PH-CG Wet meadow
- PH-CM Wet mowed turf
- Pavement

Crum Woods
Conservation and Stewardship Plan
Swarthmore College
Delaware County, Pennsylvania

Fig. 5 Plant Communities
Martin Forest

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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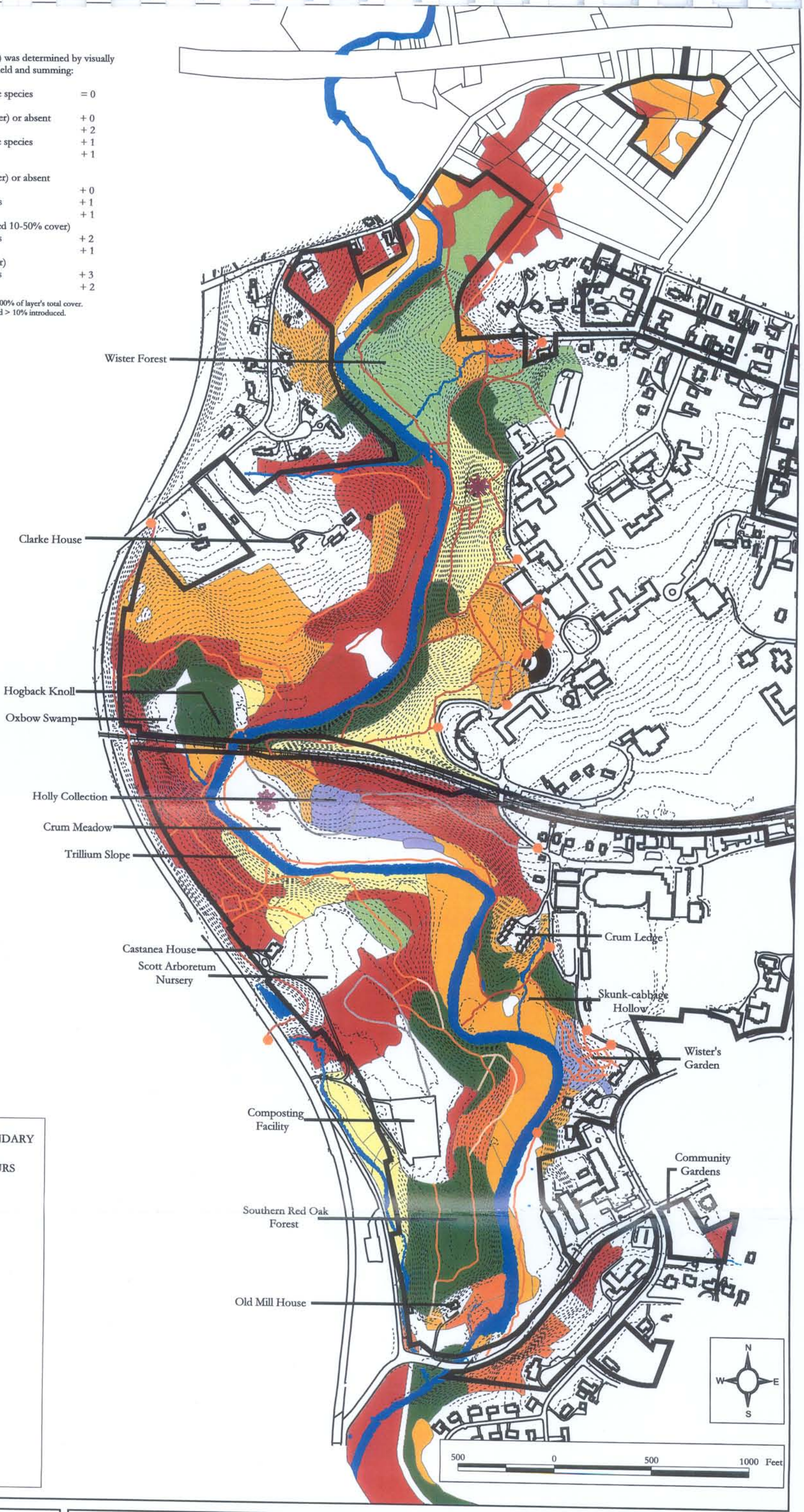
Forest invasion score (range 0-5) was determined by visually estimating species cover in the field and summing:

Entire understory mostly* native species	= 0
Subcanopy layer:	
sparse (estimated < 10% cover) or absent	+ 0
mostly* Norway maple	+ 2
mostly* other introduced tree species	+ 1
mixed†	+ 1
Shrub layer:	
sparse (estimated < 10% cover) or absent	
absent	+ 0
mostly* introduced species	+ 1
mixed†	+ 1
intermediate-density (estimated 10-50% cover)	
mostly* introduced species	+ 2
mixed†	+ 1
dense (estimated > 50% cover)	
mostly* introduced species	+ 3
mixed†	+ 2

*Mostly: species or group comprises 90-100% of layer's total cover.
†Mixed: species cover is > 10% native and > 10% introduced.



SWARTHMORE COLLEGE BOUNDARY
WATERWAYS
FIVE-FOOT INTERVAL CONTOURS
ROADWAYS
RAILROAD
BUILDINGS

VEHICULAR TRAILS
HEAVILY USED TRAILS
OTHER TRAILS
ABANDONED TRAILS
FORDS
TRAILHEADS
CRUMHENGE
ALLIGATOR ROCK

DEGREE OF FOREST INVASION BY INTRODUCED PLANT SPECIES
None
Light
Intermediate
Severe
Arboretum Planting

Crum Woods
Conservation and Stewardship Plan
Swarthmore College
Delaware County, Pennsylvania

Fig. 6 Forest Invasion by Introduced Plant Species
Campus Woods

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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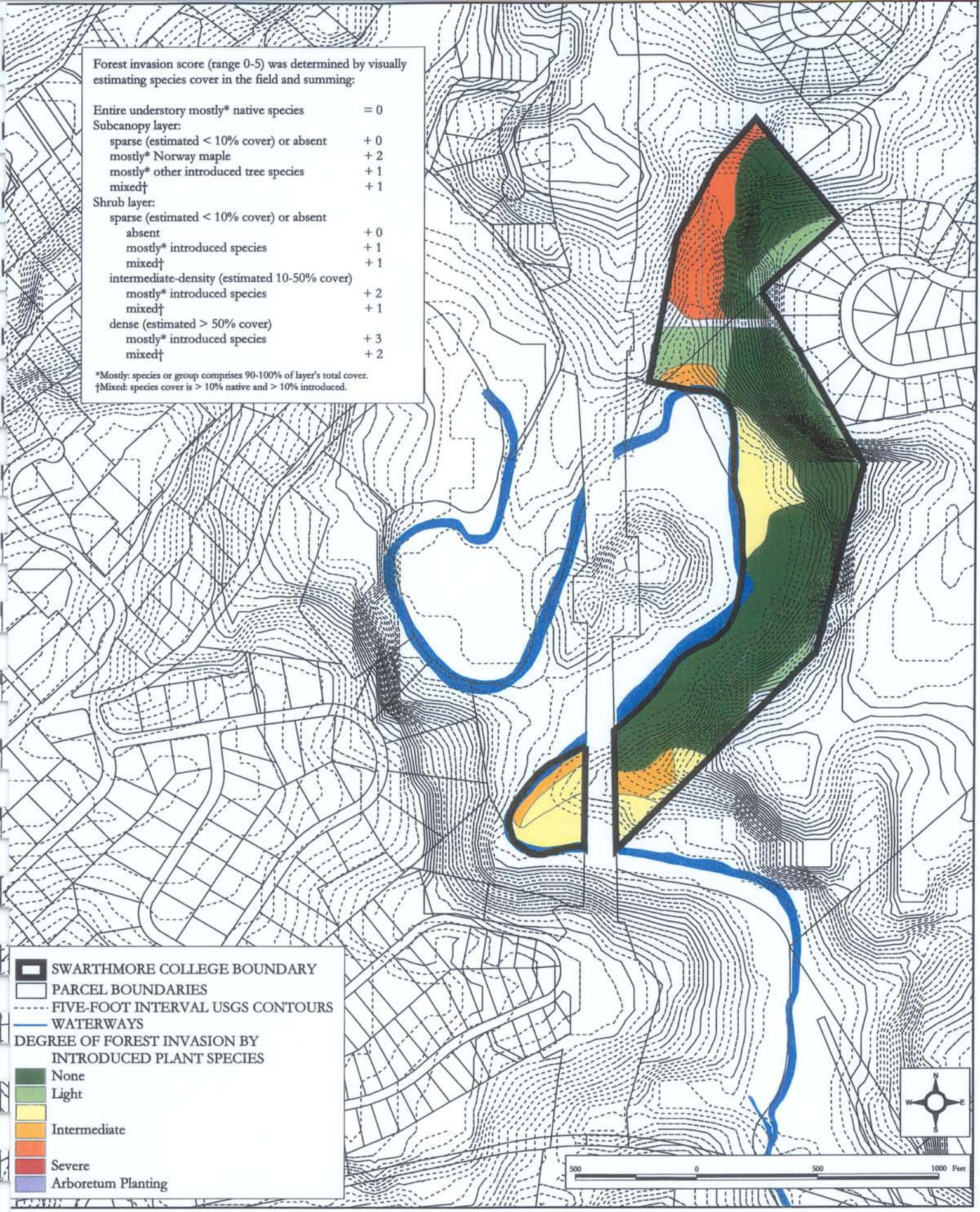

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Fig. 7 Forest Invasion by Introduced Plant Species
Martin Forest

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum bridge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, railways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways

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Fig. 8 Natural Areas
Campus Woods

Compiled By: DCR Date: 10/08/02
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
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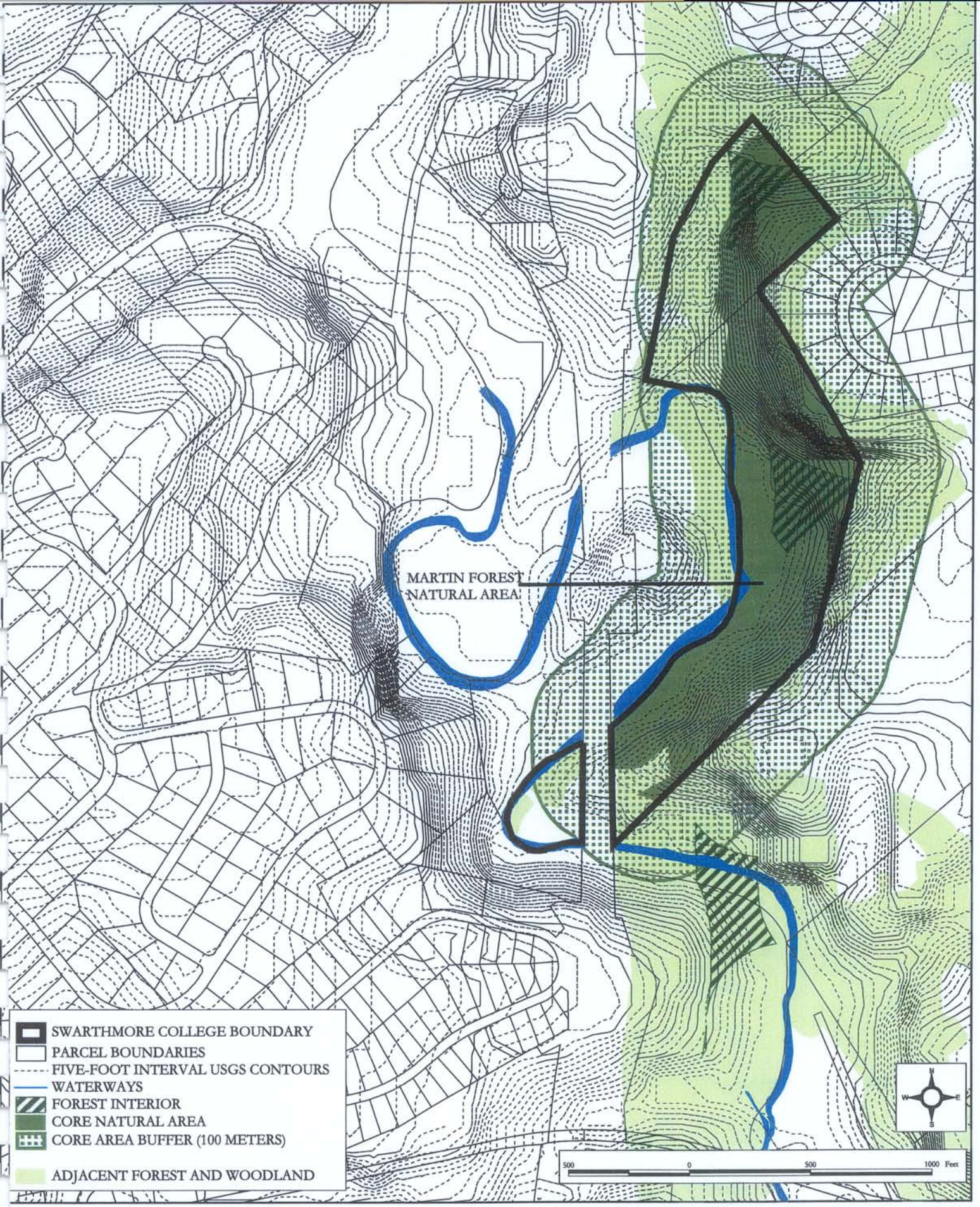

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Fig. 9

Natural Areas
Martin Forest

Compiled By: DCR Date: 12/16/03
Sources:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
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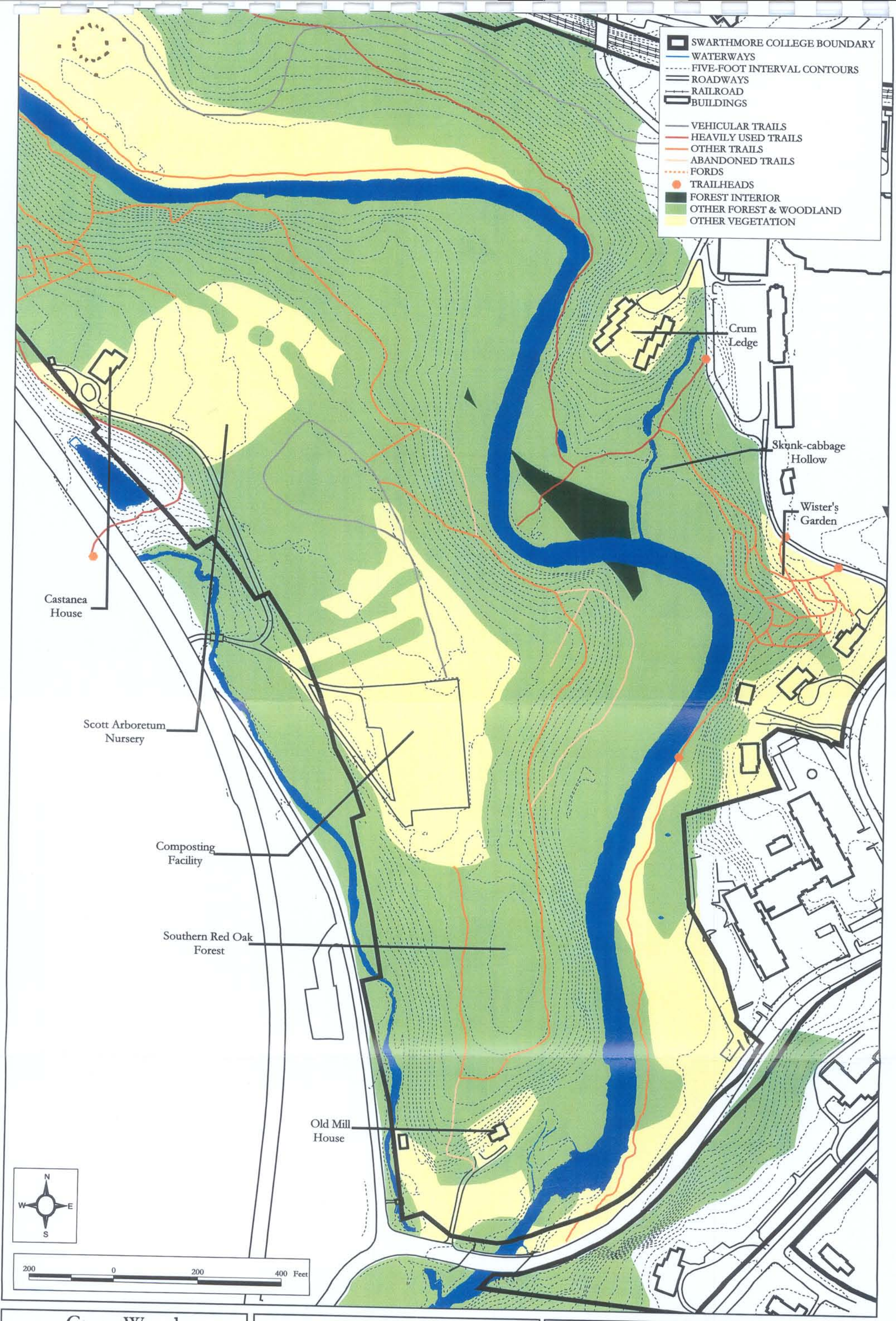

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Fig. 10 Athletic Field Scenario: Existing Conditions

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Notes:
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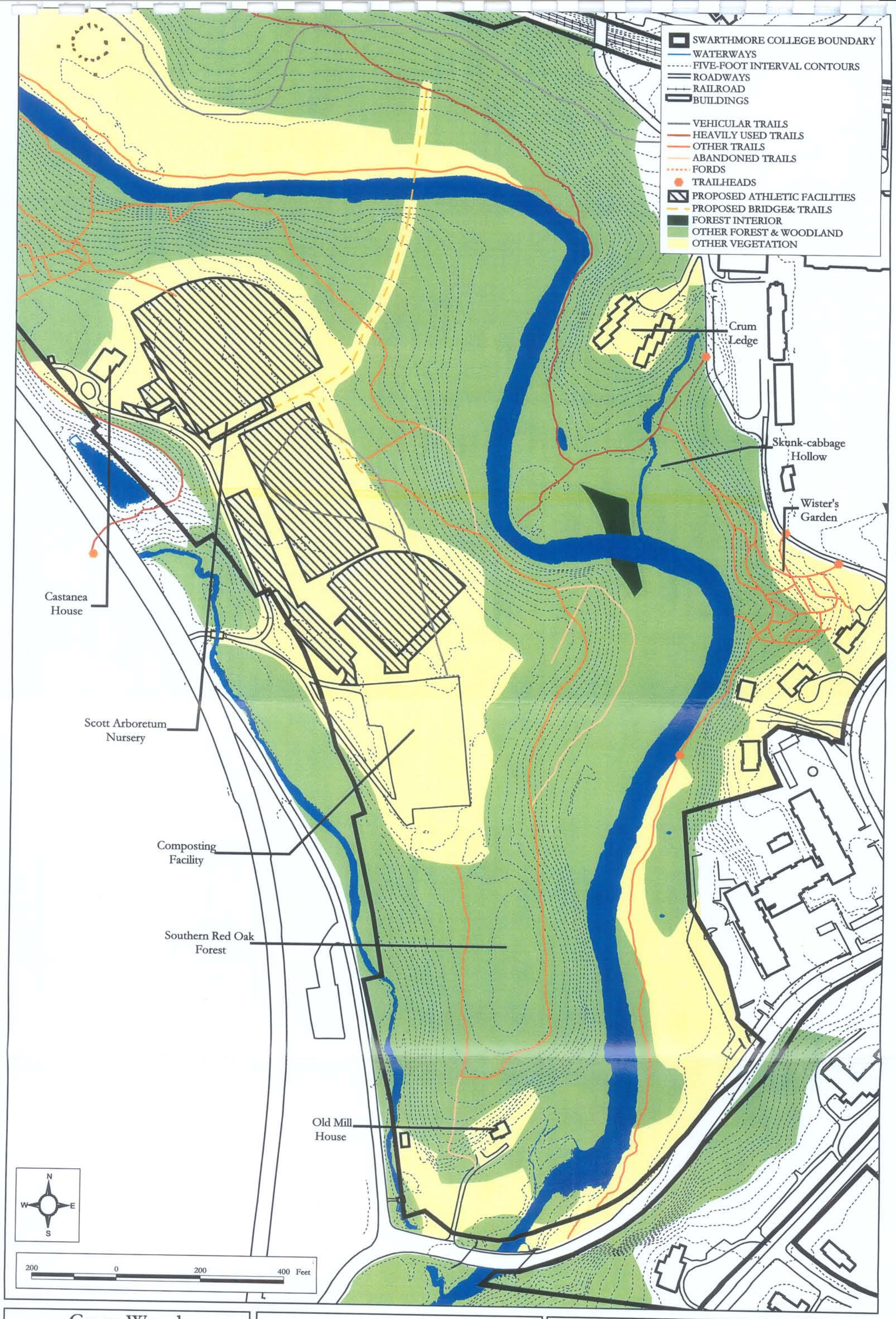

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Fig. 11 Athletic Field Scenario: Build-Out

Compiled By: DCR Date: 12/16/03

Notes:

1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
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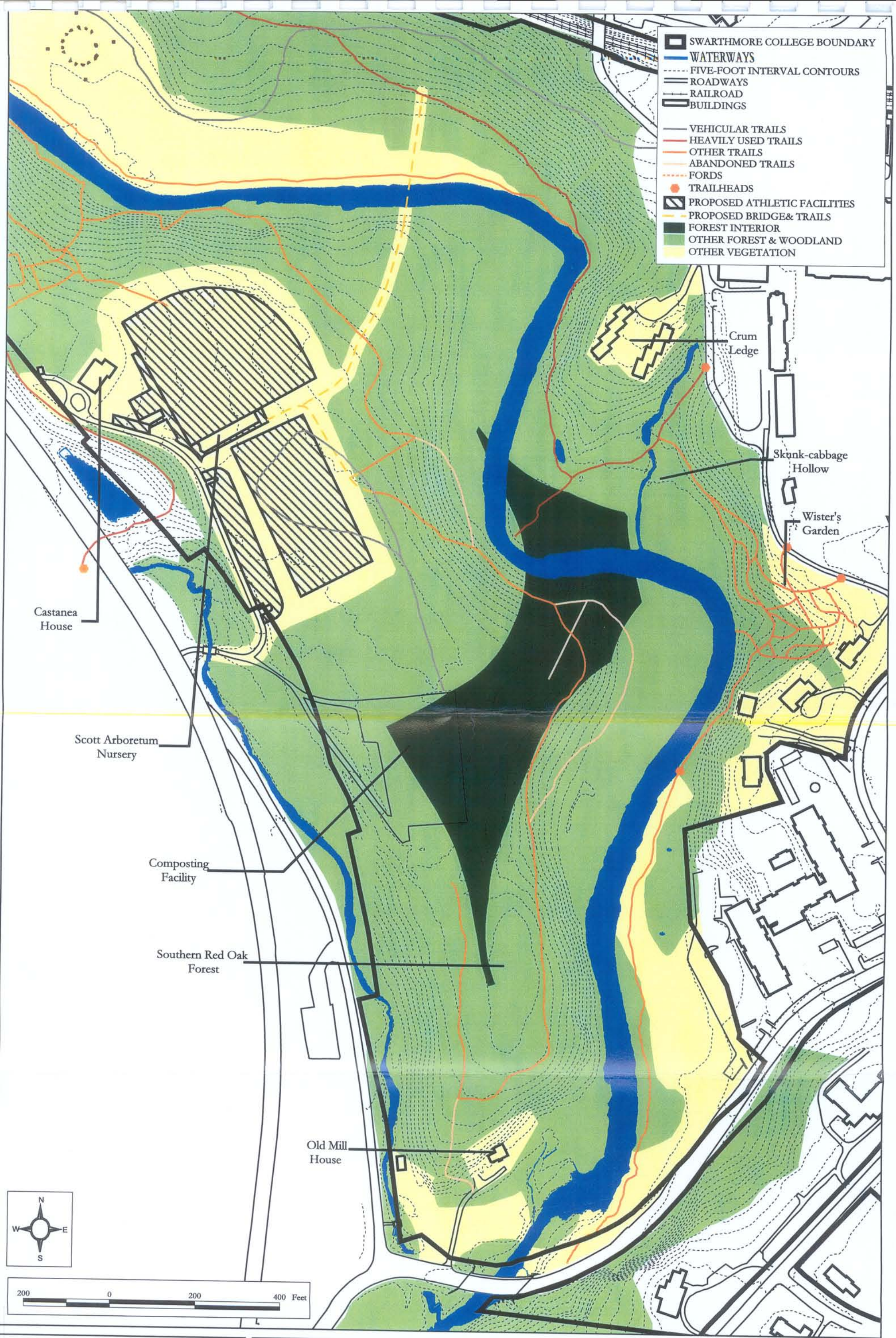

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Fig. 12 Athletic Field Scenario: Modified Plan I

Compiled By: DCR Date: 10/10/02
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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Fig. 13 Athletic Field Scenario: Modified Plan II

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
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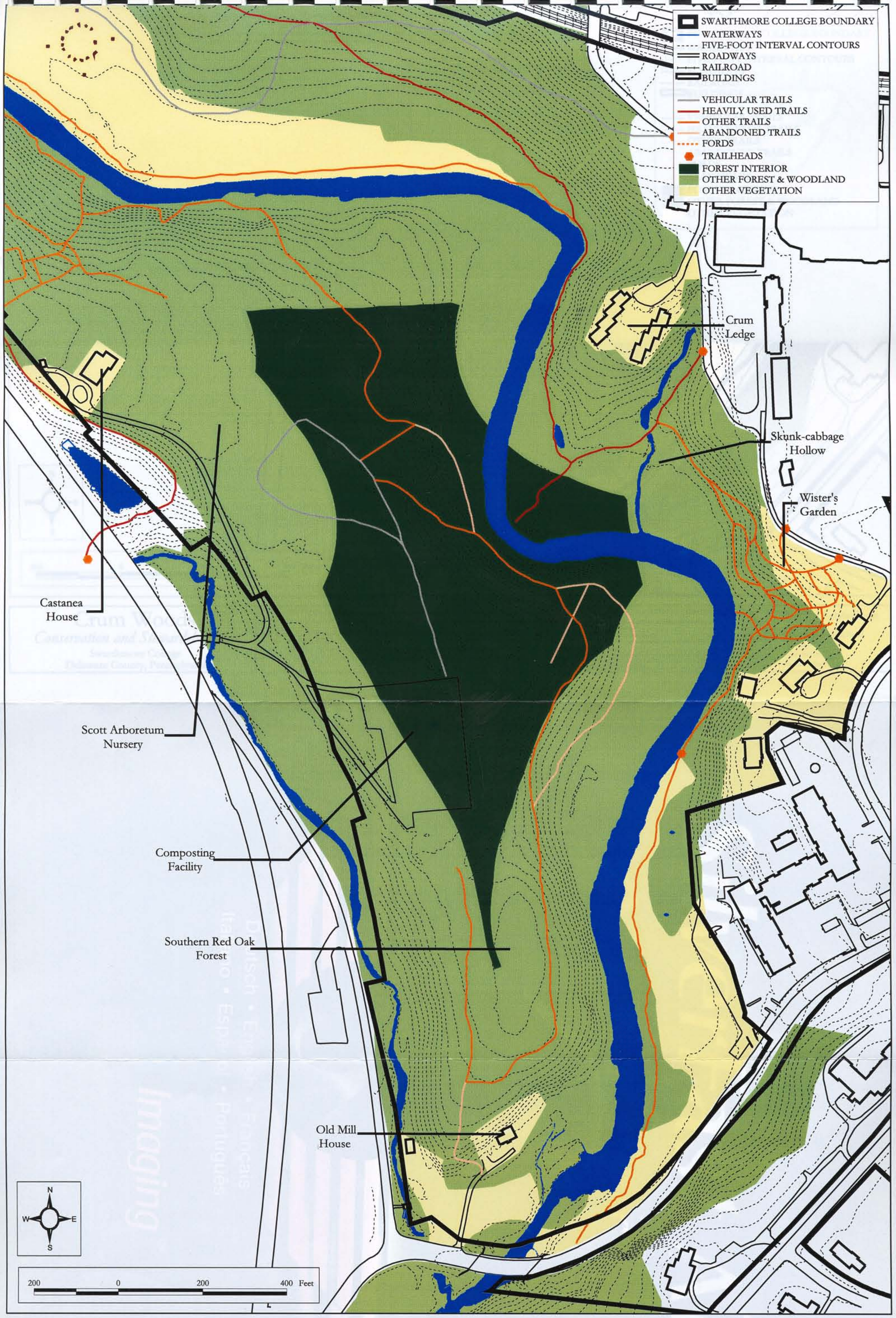

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Fig. 14 Athletic Field Scenario: Reforestation I

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Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
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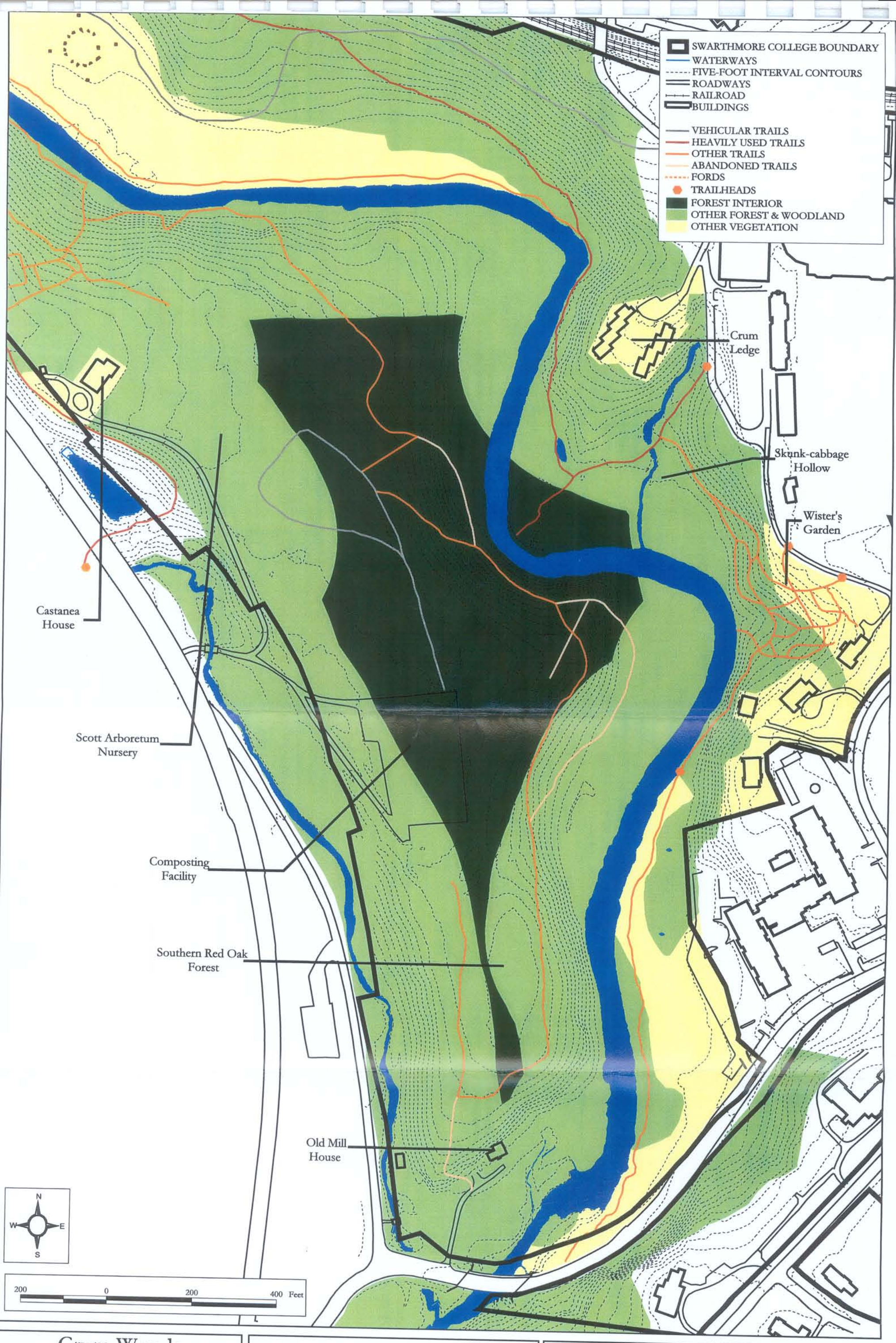

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Fig. 15 Athletic Field Scenario: Reforestation II

Compiled By: DCR Date: 12/16/03

Notes:

1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.

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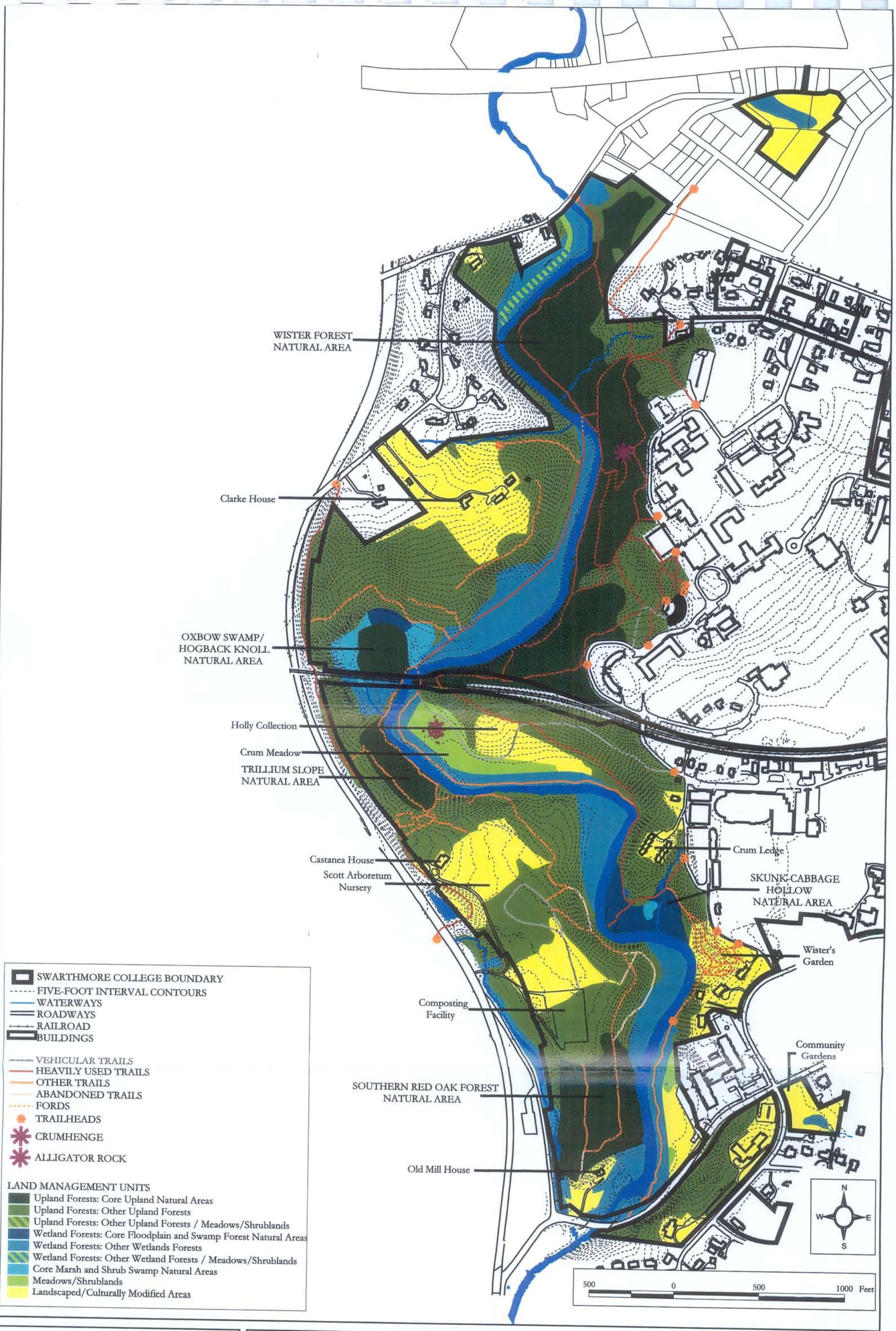

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Fig. 16 Land Management Units
Campus Woods

Compiled By: DCR Date: 09/26/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
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3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
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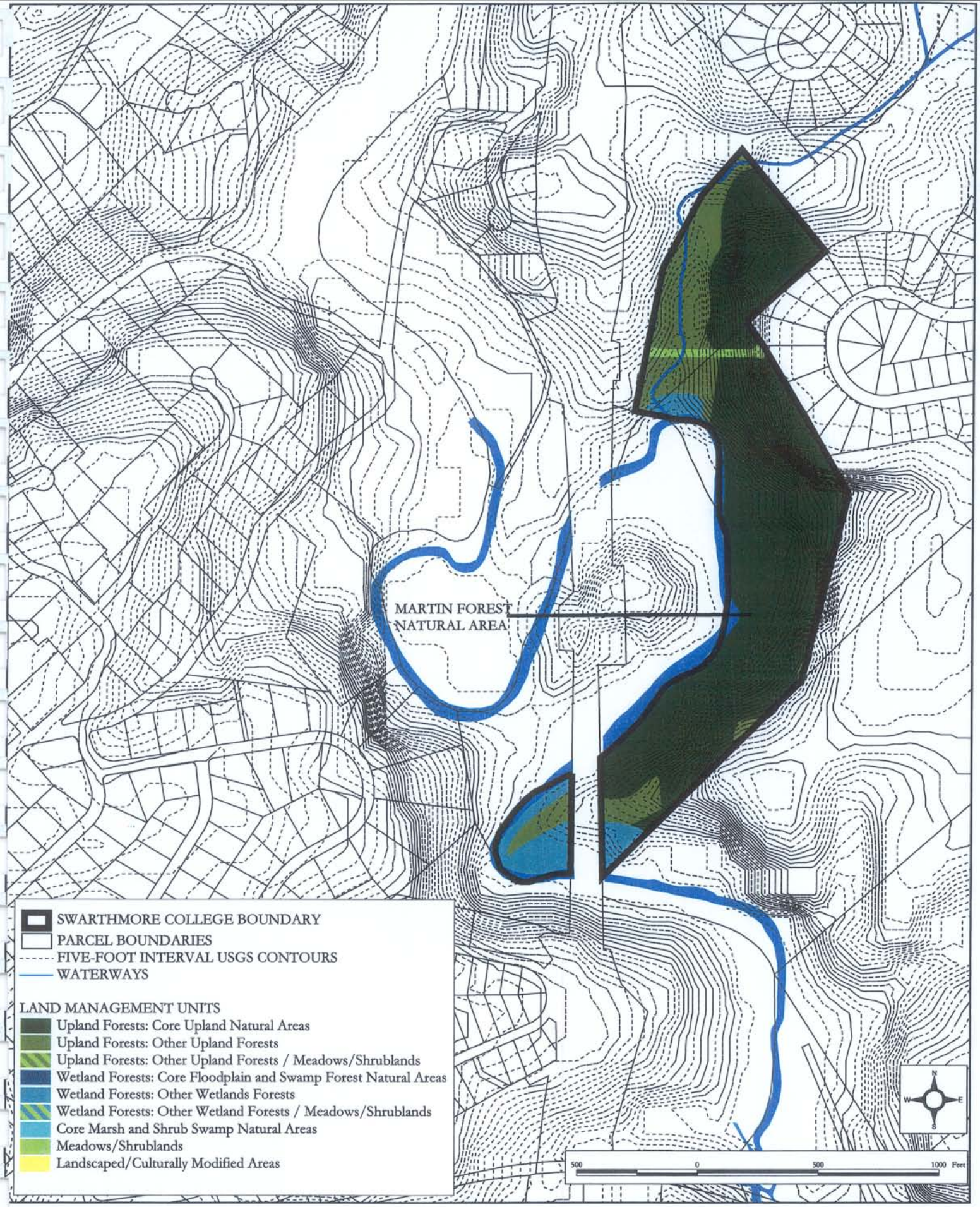

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Fig. 17

Land Management Units
Martin Forest

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and creek bridges received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Allegheny Rock, garden nuts, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Vegetation Communities located by Roger Latham using 1991 infra-red aerial photograph then digitized, placed and shape-warped using waterways and parcel boundaries. Roger Latham then performed on-site verification.

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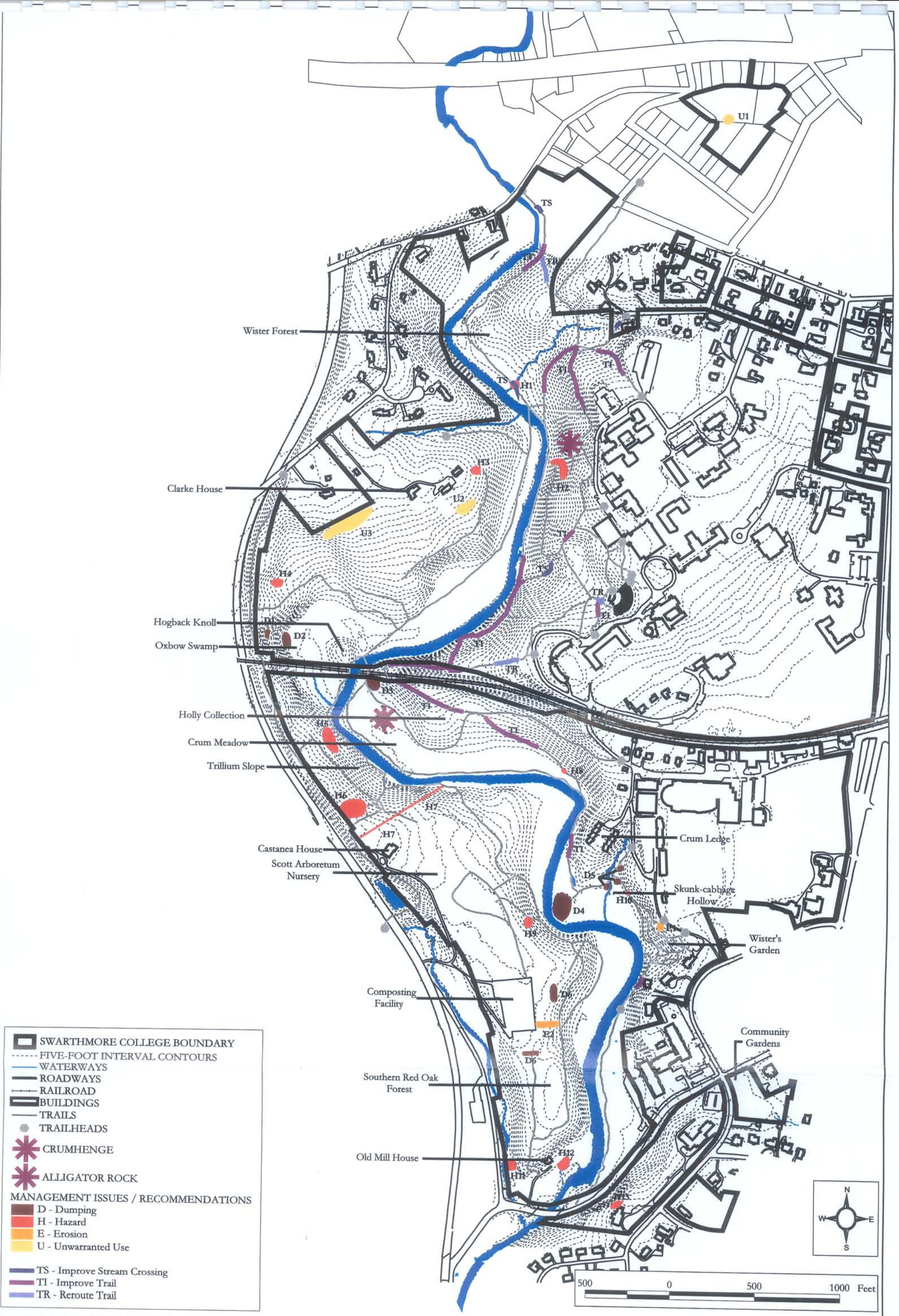

SWARTHMORE COLLEGE BOUNDARY
FIVE-FOOT INTERVAL CONTOURS
WATERWAYS
ROADWAYS
RAILROAD
BUILDINGS
TRAILS
TRAILHEADS
CRUMHENGE
ALLIGATOR ROCK

MANAGEMENT ISSUES / RECOMMENDATIONS
D - Dumping
H - Hazard
E - Erosion
U - Unwarranted Use

TS - Improve Stream Crossing
TI - Improve Trail
TR - Reroute Trail

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Fig. 18

Management Issues / Recommendations
Campus Woods

Compiled By: DCR
Date: 09/19/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum henge received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Alligator Rock, garden ruin, trailways, trailheads, and debris piles located with GPS by Roger Latham.
4. Stewardship Issues compiled by David Steckel and digitized at NLT.

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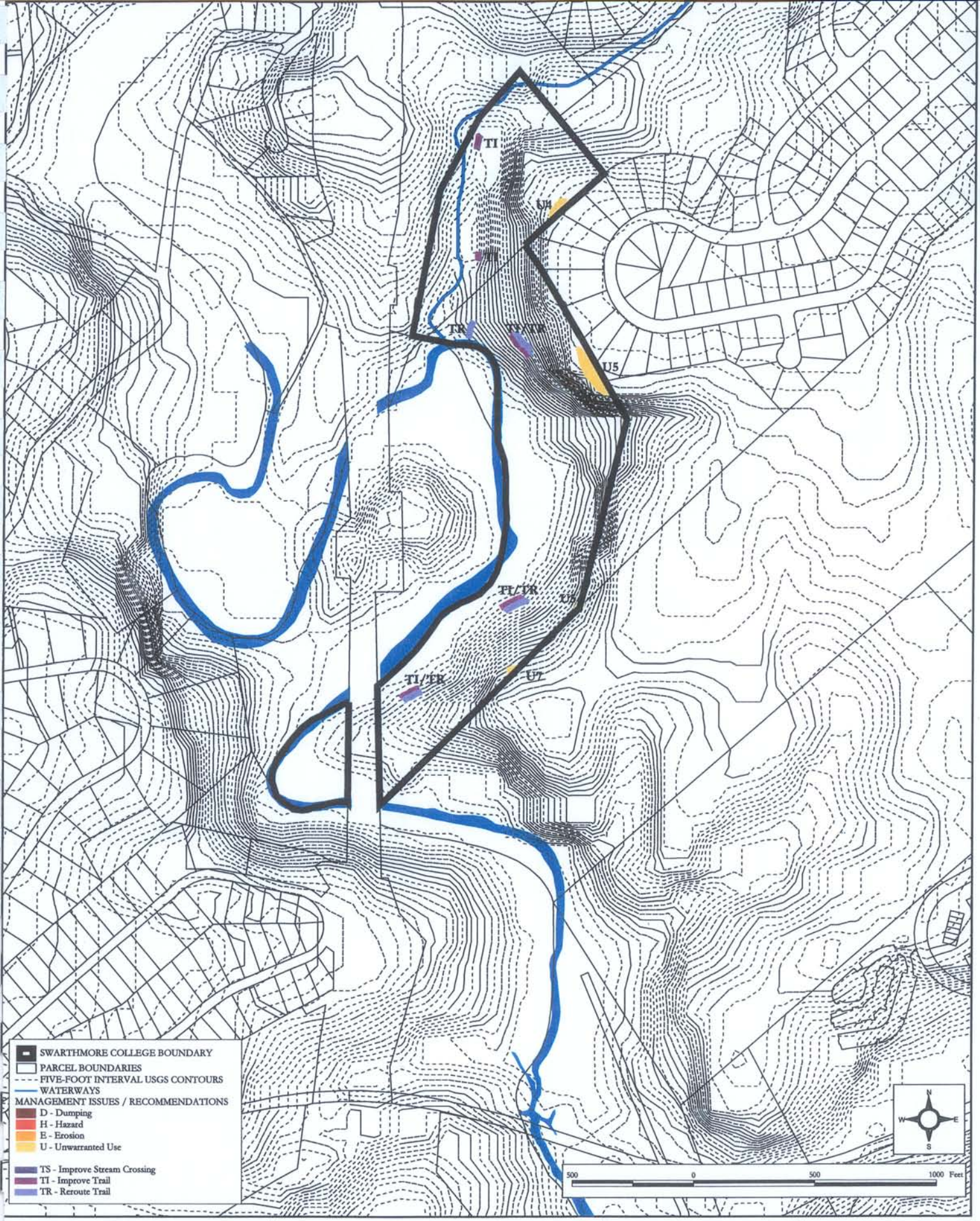

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Fig. 19 Management Issues / Recommendations
Martin Forest

Compiled By: DCR Date: 12/16/03
Notes:
1. Waterways, contours, roadways, railroad, buildings, and crum boogs received from Swarthmore College.
2. Parcel boundaries from Delaware County.
3. Allegany Rock, garden rain, walkways, trailheads, and debris piles located with GPS by Roger Latham.
4. Stewardship Issues compiled by David Steckel and digitized at NLT.

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